form cutting across the sandy tuff part in a N15～30°E-70°NW direction. This weak altered area has been replaced by halloysite and montmorillonite-illite mixed layer minerals.

Small-scale quartz veins and rocks with disseminations of sulfides, other than those mentioned above, are found here and there in the Chiang Khong area.. Their assay values have been compiled in appendix table 7.

1-6 Geochemical Prospecting

1-6-1 Sample collecting and pathfinder elements

To ensure coverage of the whole survey area, the principal rivers and their tributaries were selected in advance and sampling was carried out in parallel with the geological survey. As a rule there was a distance of 350～450m between sampling points. Stream sedimemt from the middle of the stream at each sampling point was put through an 80-mesh screen and 100～150g of samples through 80-mesh sieves was collected. 698 samples were taken. The location of the sampling points is shown in PL-2, together with the locations where panning samples and rock samples were taken. After air-drying, the samples were divided between the Thai and Japanese teams and one part was submitted for Chemical analysis. As the main purpose of this survey was to extract base metal deposits containing gold, 12 elements were taken as pathfinder elements: Au, Ag, Cu, Pb, Zn, Hg, As, Fe, S, W, Sb and Mn. The detected limit values of each element are shown in Table 4.

1-6-2 Analysis of analytical data

1. Processing of Statistics

It is known that if the analytical accuracy is sufficiently reliable, the geochemical analytical values in general, and the micro components in particular, show a distribution close to the lognormal distribution. Therefore, common logarithm values were used to analyze the analytical values below. For reasons of statistical processing, half of the analytical values below the minimum detected critical values were used. The maximum value, minimum value, average value and standard deviation of each element are shown in Table 4. And the frequency distribution and cumulative frequency curve map is shown in Fig. 11. The classification of frequency distribution is $1/2\sigma$. This is the same for the Doi Chong and Ratchaburi areas.

The correlation coefficients for each element are shown in Table 5.

A strong positive correlation is evident in the Cu-Zn-Fe-(Mn) group, Pb-Zn-Fe-Mn group and Fe-W-Mn group. A weak positive correlation is also evident in the As-Sb group. On the other hand, neither a positive nor a negative correlation of the 4 elements, Au, Ag, Hg and S, with the other elements is seen.

2. Deciding the thresholds

As shown by Lepeltier (1969), Sinclair (1976), and Govett et al. (1983), various methods have been devised to decide the thresholds which divide the anomaly values from the background values in geochemical data, including using the natural breaks in frequency distribution, the turning points in the cumulative frequency distribution curve, the average values and standard deviation, or the percen-

tile of frequency distribution.

Table 4 Basic statistic quantities of stream sediments in Chiang Khong area

element	unit	Detection limit	Maximum	MInimum	Average	Standard deviation
Au	ppb	1	1660	< 1	1.05	0.5665
Ag	ppm	0.1	1.2	< 0.1	0.10	0.0618
Cu	ppm	1	102	< 1	8.83	0.3479
Pb	ppm	2	84	< 2	15.79	0.2558
Zn	ppm	2	106	< 2	36.27	0.2985
Hg	ppb	10	25000	< 10	23.41	0.4609
As	ppm	2	222	< 2	4.25	0.4852
Fe	%	0.01	12.3	0.23	3.33	0.2518
S	%	0.01	0.25	<0.01	0.008	0.2115
W	ppm	10	40	< 10	6.05	0.1609
Sb	ppm	2	32	< 2	1.46	0.2278
Mn	ppm	5	2390	10	497.30	0.3249

Table 5 Geochemical correlation coefficients of stream sediments in Chiang Khong area

Au	1.0000											
Ag	0.1874	1.0000										
Cu	0.0851	-0.0051	1.0000									
Pb	0.0357	0.0578	0.0428	1.0000								
Zn	0.0904	0.0143	0.6200	0.4757	1.0000							
Hg	0.1075	0.0851	0.1349	0.2691	0.2594	1.0000						
As	0.0078	-0.0626	0.1500	0.0647	0.1283	0.0604	1.0000					
Fe	0.0098	0.0433	0.5758	0.4811	0.7638	0.2739	0.1144	1.0000				
S	0.0649	0.0455	0.1503	0.0435	0.2133	0.1897	-0.0039	-0.0159	1.0000			
W	0.1289	-0.0596	0.2683	0.2626	0.2855	0.0783	0.0050	0.4283	-0.0704	1.0000		
Sb	0.0419	-0.0562	0.1646	0.0989	0.1598	0.2149	0.3563	0.2804	0.0317	-0.0692	1.0000	
Mn	0.0494	0.0746	0.3788	0.4679	0.6474	0.2392	0.1512	0.7607	0.0250	0.2821	0.1614	1.0000
	Au	Ag	Cu	Pb	Zn	Hg	As	Fe	S	W	Sb	Mn

In this analysis, taking mainly the average values and standard deviation as the standard, we added the frequency distribution and cumulative frequency curve map to determine the thresholds. The threshold for each element is shown in Table 6. The negative anomaly zones for Cu, Pb, Zn, Fe, As and Mn were also set.

3. Distribution of the Anomal Zones

The anomayl zone distribution map was drawn up based on the divisions in Table 6 (Fig. 12). The anomaly distribution for each element is explained below.

[Au]

The high anomaly zone for gold is particularly marked in the north of the Chiang Khong area and anomaly zones are distributed in the upper reaches of Nam Khon Kaen and Nam Sala, and in Nam Mae Bong, Nam Thung Lo, etc. With the exception of Nam Mae Bong, these anomaly zones are in harmony with the alteration zones seen in this area and are also closely connected with the faults which accompany andesite activity. These gold anomalies are thought to have been formed in connec-

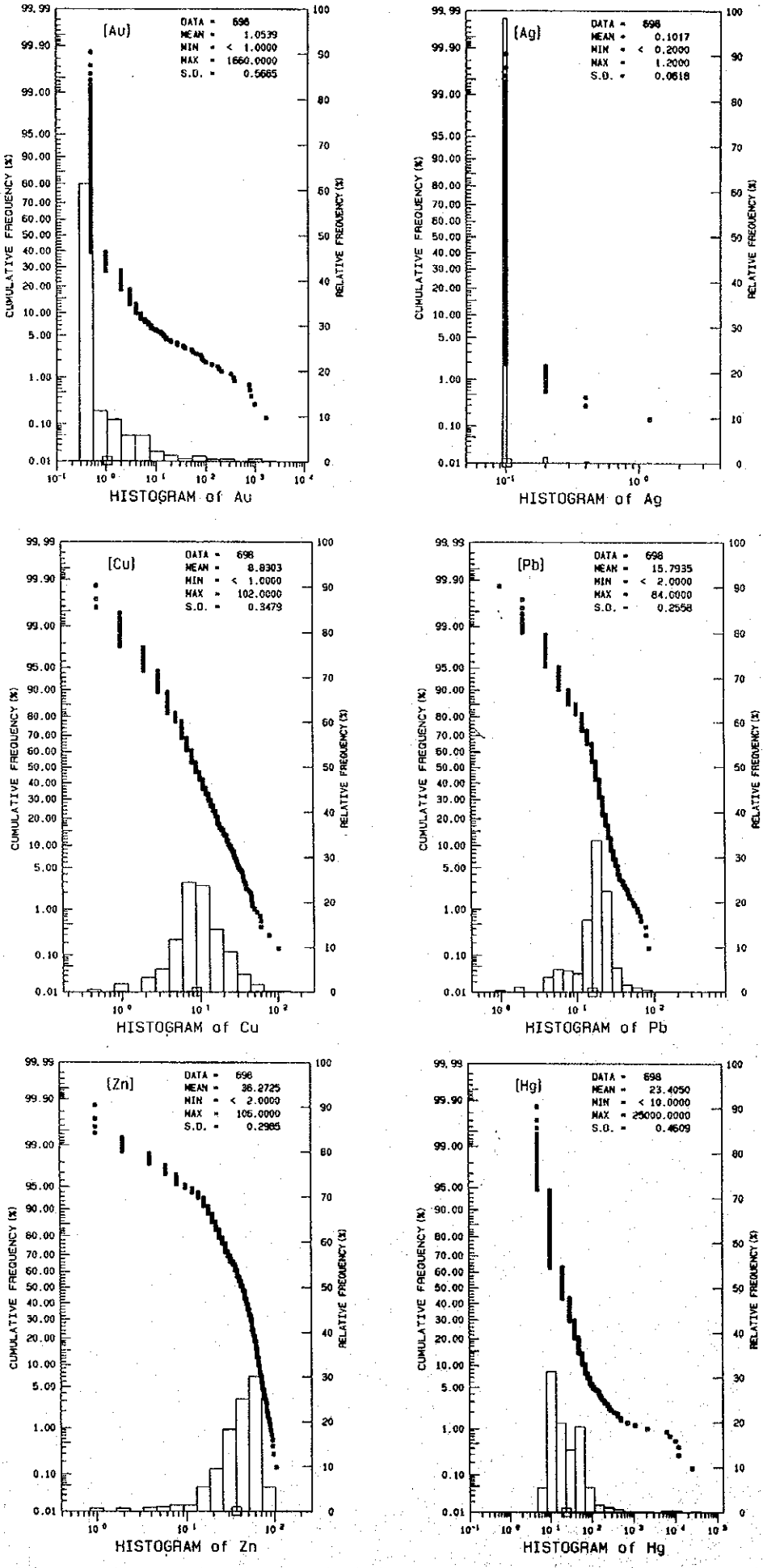


Fig.11 Relative frequency and cumulative frequency histogram of stream sediments in Chiang Khong area (1)

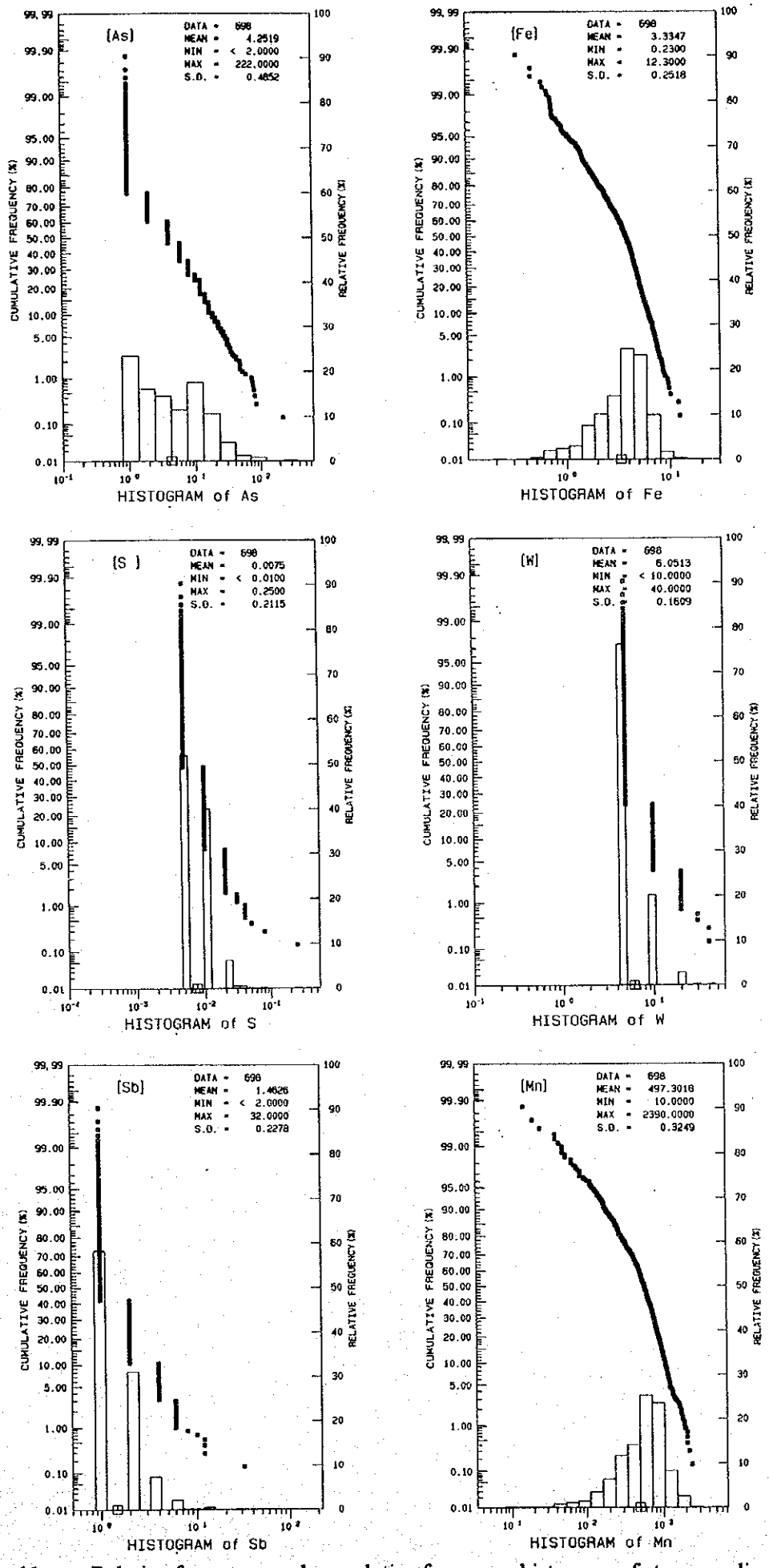


Fig.11 Relative frequency and cumulative frequency histogram of stream sediments in Chiang Khong area (2)

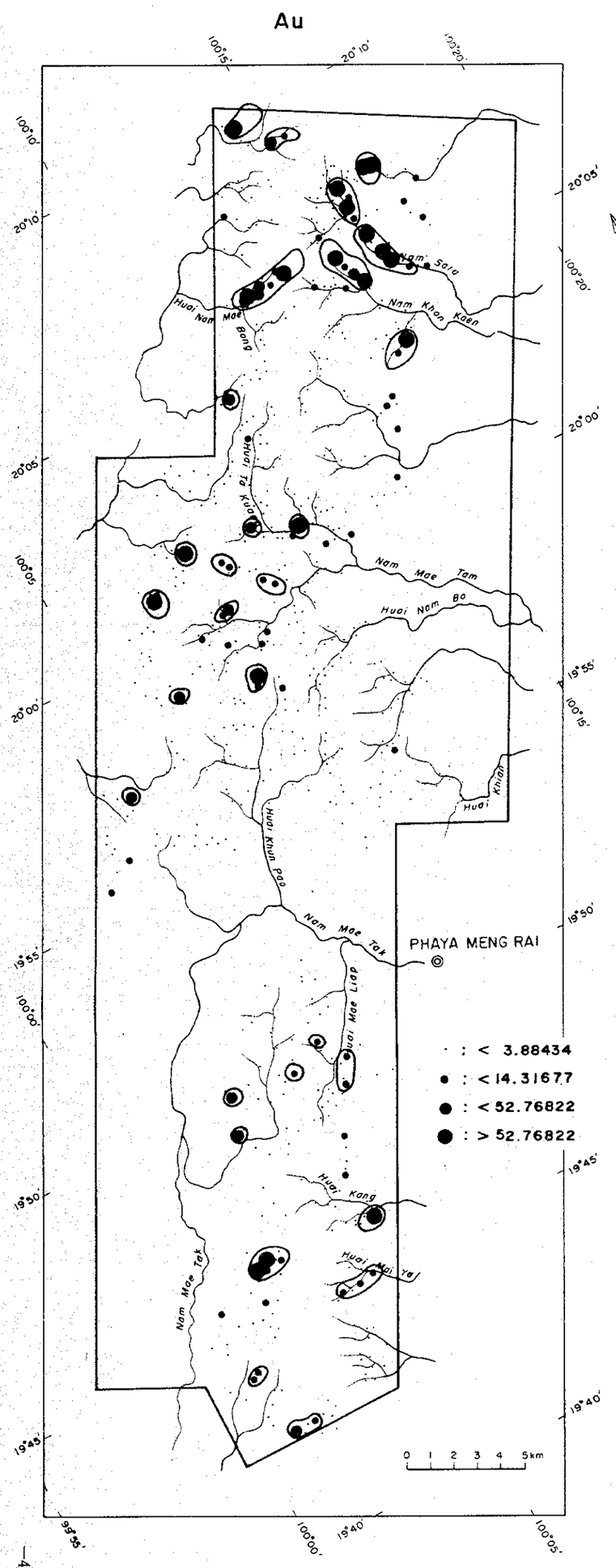
tion with the formation of the alteration zones and the activity of andesite. Similar anomaly zones, though smaller in scale, are seen on the south side of Nam Khon Kaen. Judging from the fact that the upper reaches of Nam Mae Bong are close to the anomaly zone in the upper reaches of Nam Sala, it is likely that the anomaly zone of Nam Mae Bong is a secondary anomal zone that flowed from the same anomaly zone.

Table 6 Division into geochemical anomaly levels of stream sediments in Chiang Khong area

element	unit	low anomaly	background	high anomaly 1	high anomaly 2	high anomaly 3
Au	ppb		M+σ 3.88	M+2 σ 14.32	M+3 σ 52.77	
Ag	ppm		M+σ 0.103			
Cu	ppm	M-1.5 σ 2.65	M+1.5 σ 29.36			
Pb	ppm	M-1.5 σ 6.53	M+1.5 σ 38.21			
Zn	ppm	M-σ 18.24	M+σ 72.13			
Hg	ppb		M+σ 67.64	M+2.5 σ 332.32		
As	ppm	M-0.5 σ 2.43	M+σ 13.00	M+2 σ 39.72		
Fe	%	M-1.5 σ 1.40	M+σ 5.96	M+1.5 σ 7.96		
S	%		M+2 σ 0.02			
W	ppm		M+1.5 σ 10.55			
Sb	ppm		M+1.5 σ 3.21			
Mn	ppm	M-2 σ 111.38	M+σ 1050.8			

Anomaly zones of gold are distributed here and there in the north of the area, but each anomaly zone only has one or two anomalies and no large anomaly zone is shown. The anomalies are distributed near faults or on the extensions of faults, suggesting that they show gold minralization along these fractures.

The anomaly values in the middle reaches of Nam Mae Tam are close to the pit where placer gold was once mined. Anomalies are scattered in the vicinity of the boundary between granite and sedimentary rock in the south of the area. Here too the anomalies show no large distribution. Large anomaly zones are seen in Huai Mae Liap southwest of Phaya Men Rai and Huai Pla on the west side of the granite body. Four anomaly values are concentrated at Huai Pla and 1,660 ppb, the highest



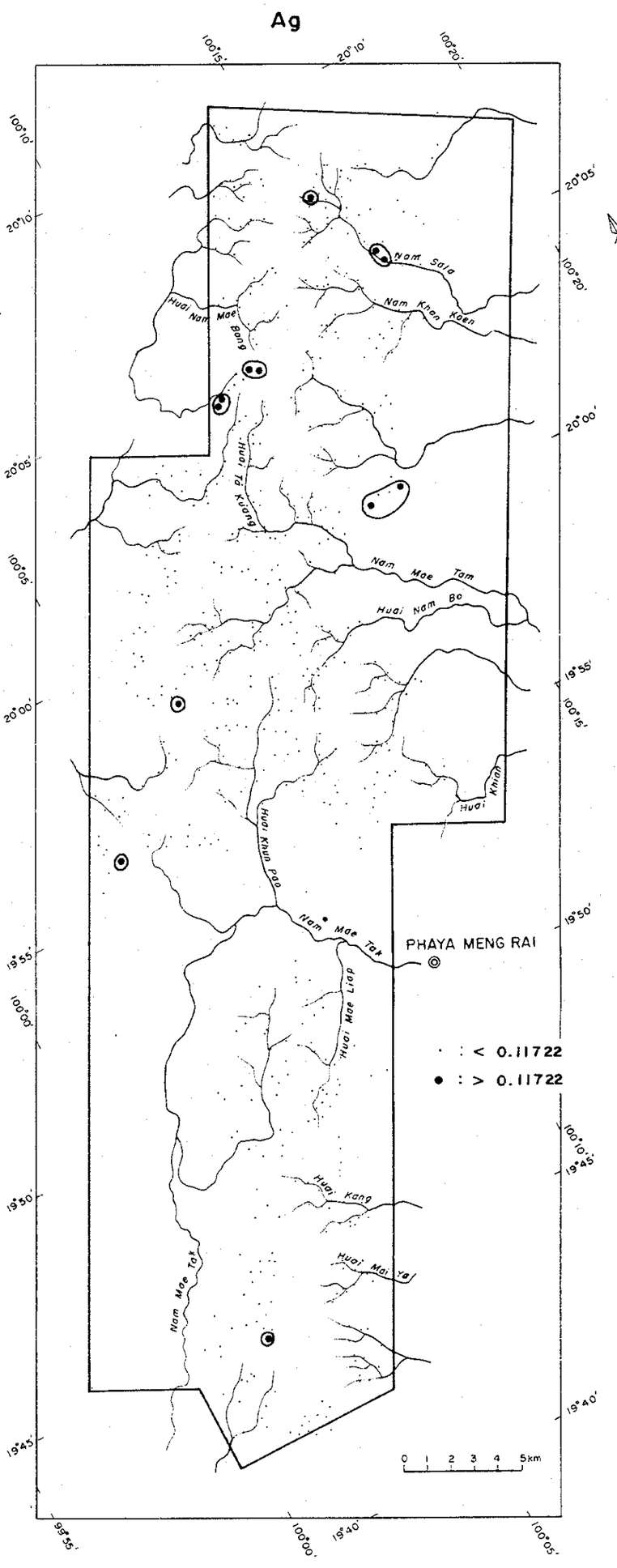
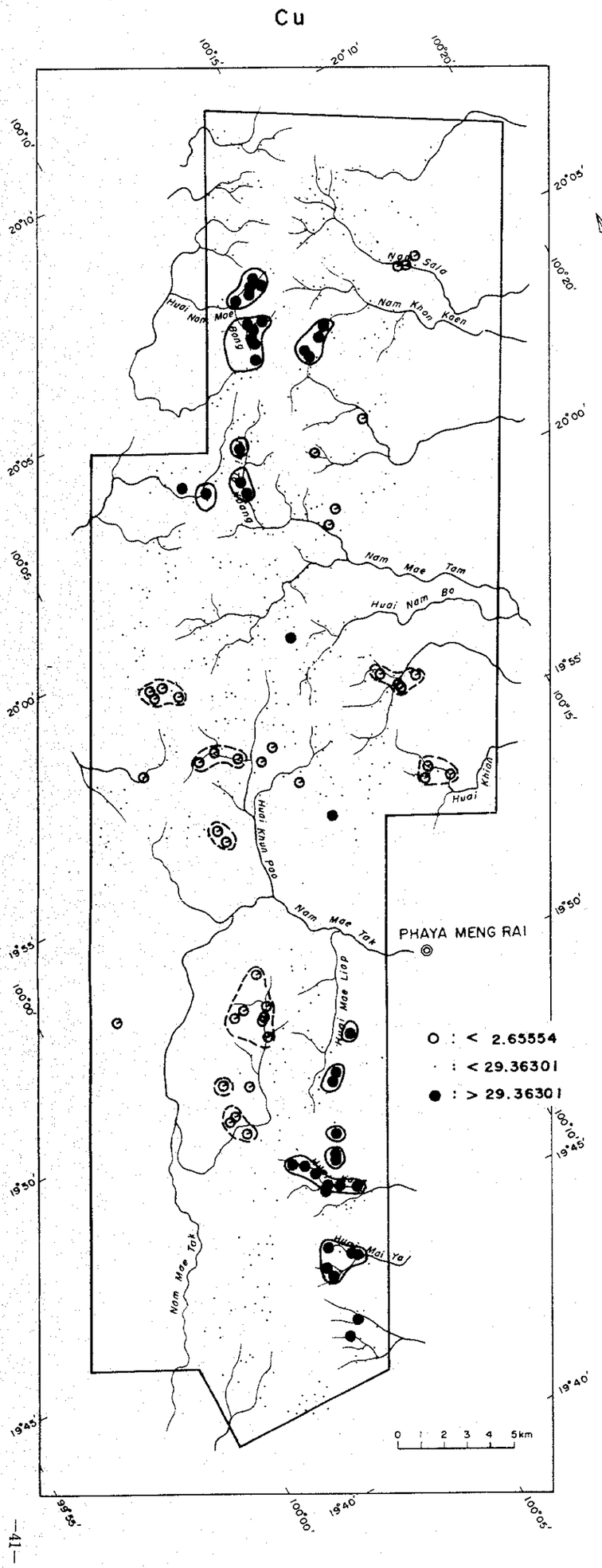


Fig. 12 Geochemical anomaly map of stream sediments in Chiang Khong area (1)



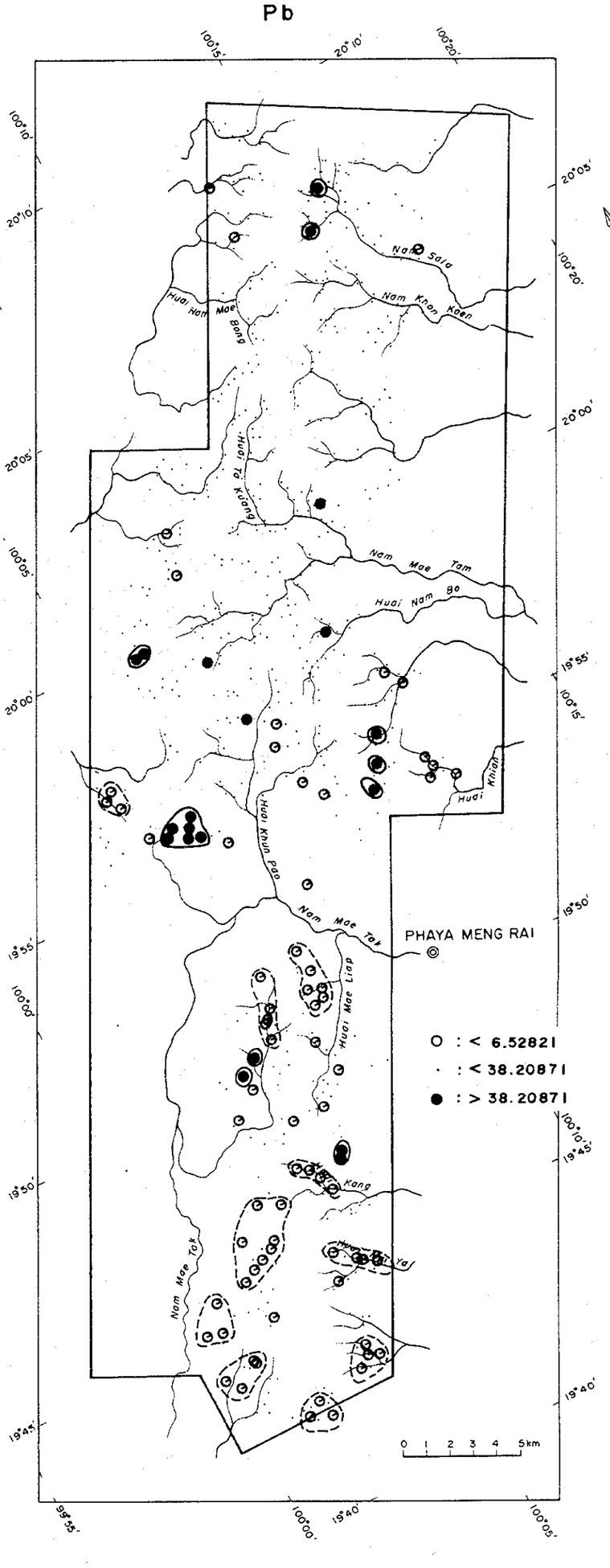
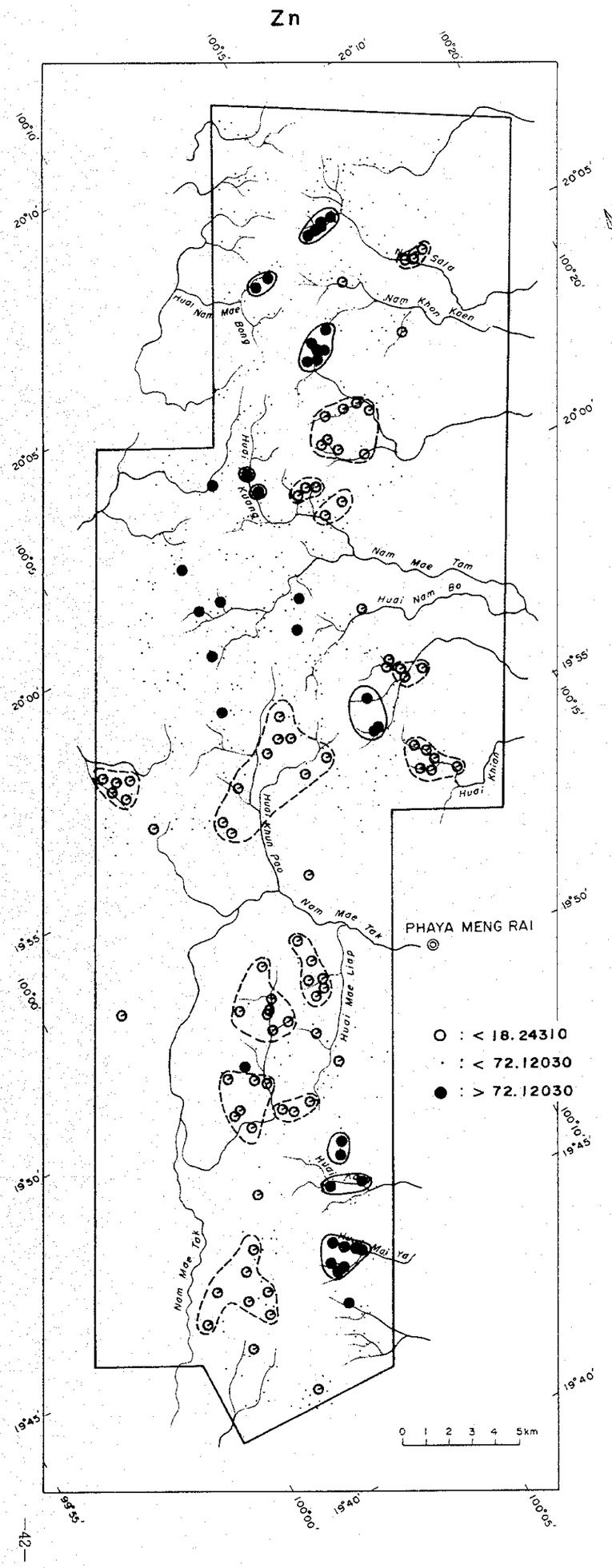


Fig.12 Geochemical anomaly map of stream sediments in Chiang Khong area (2)



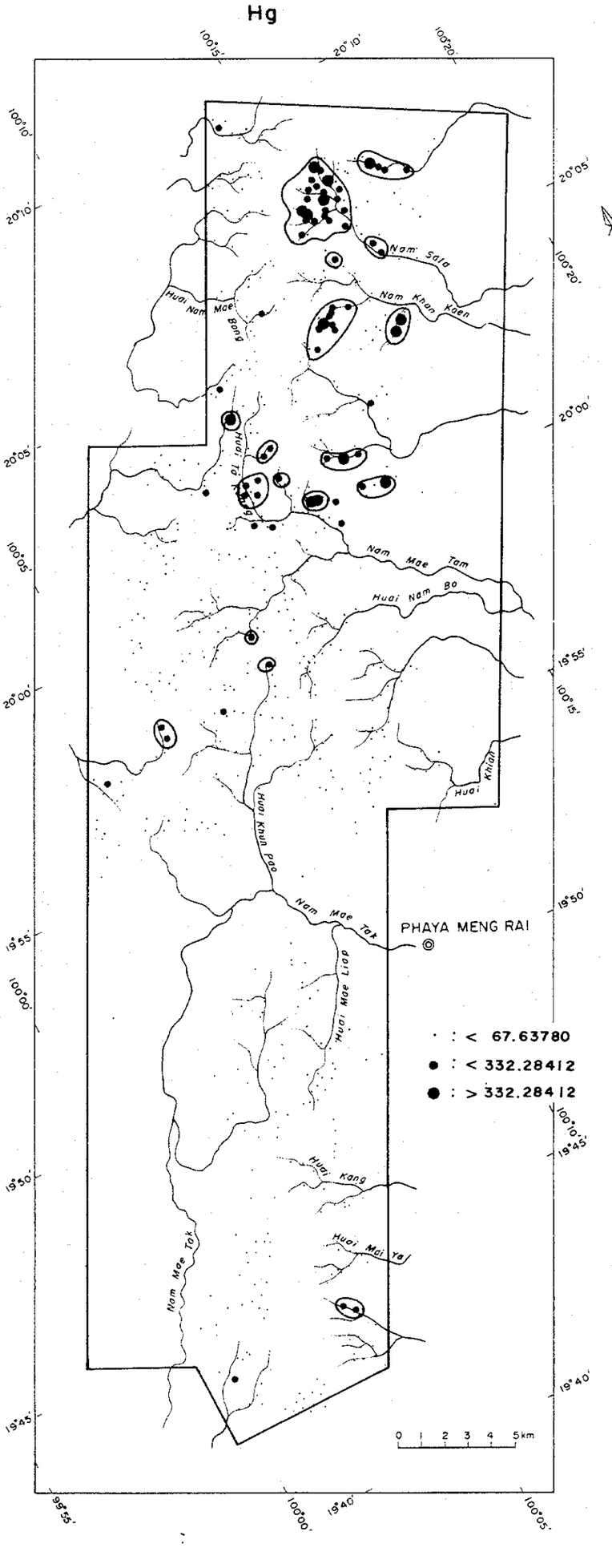


Fig.12 Geochemical anomaly map of stream sediments in Chiang Khong area (3)

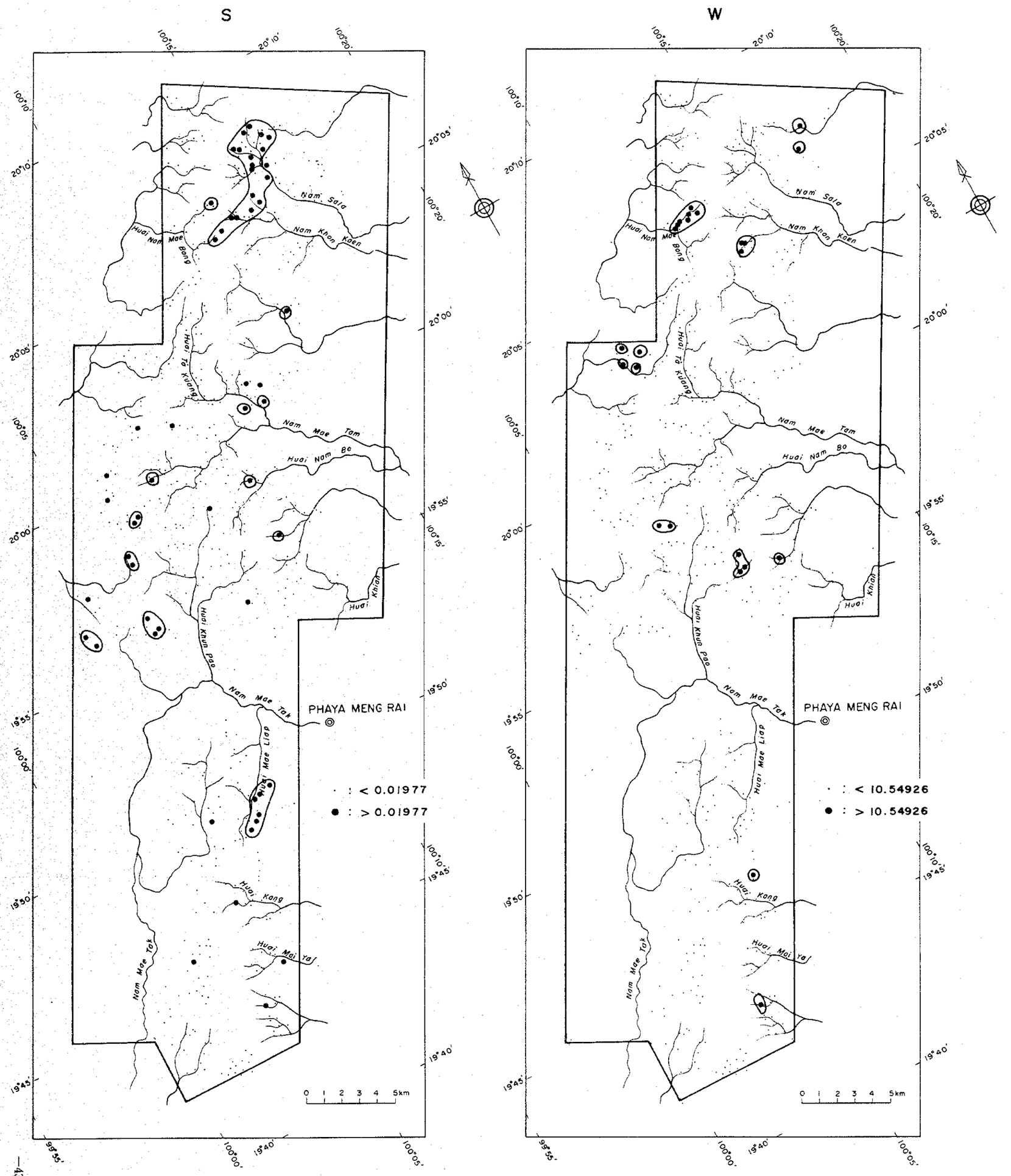
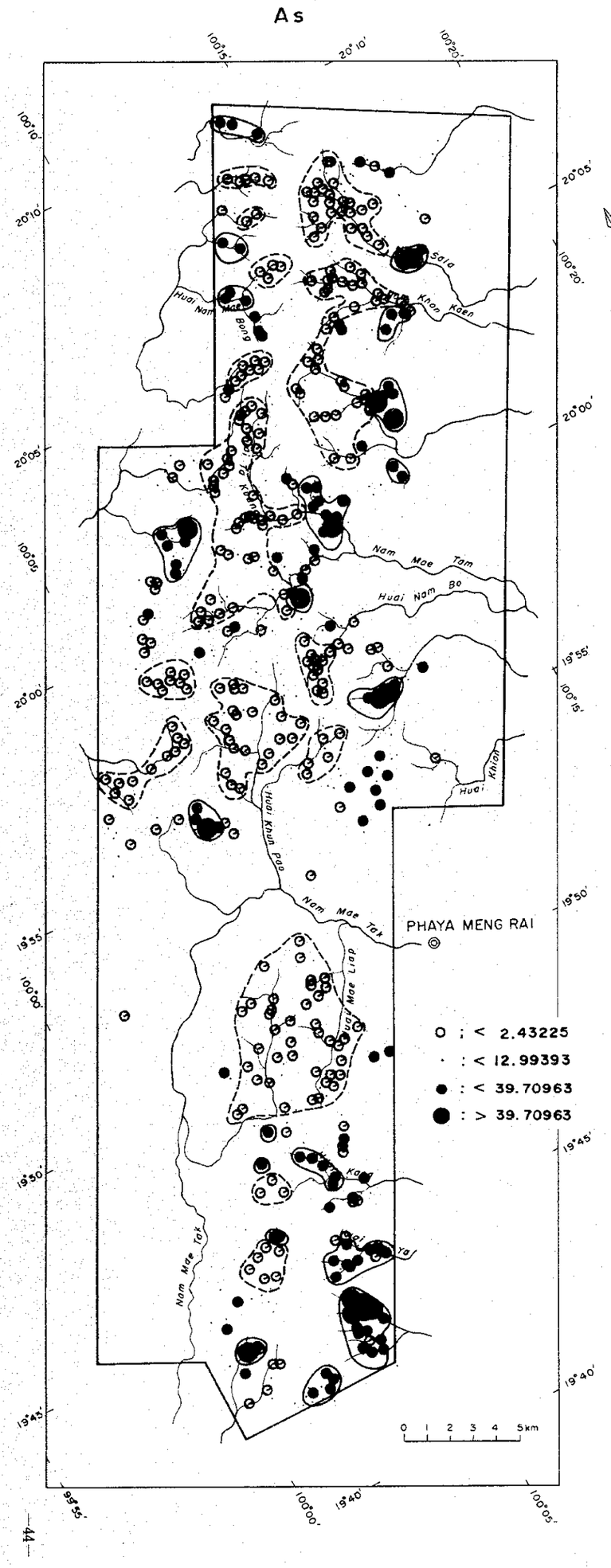


Fig. 12 Geochemical anomaly map of stream sediments in Chiang Khong area (4)



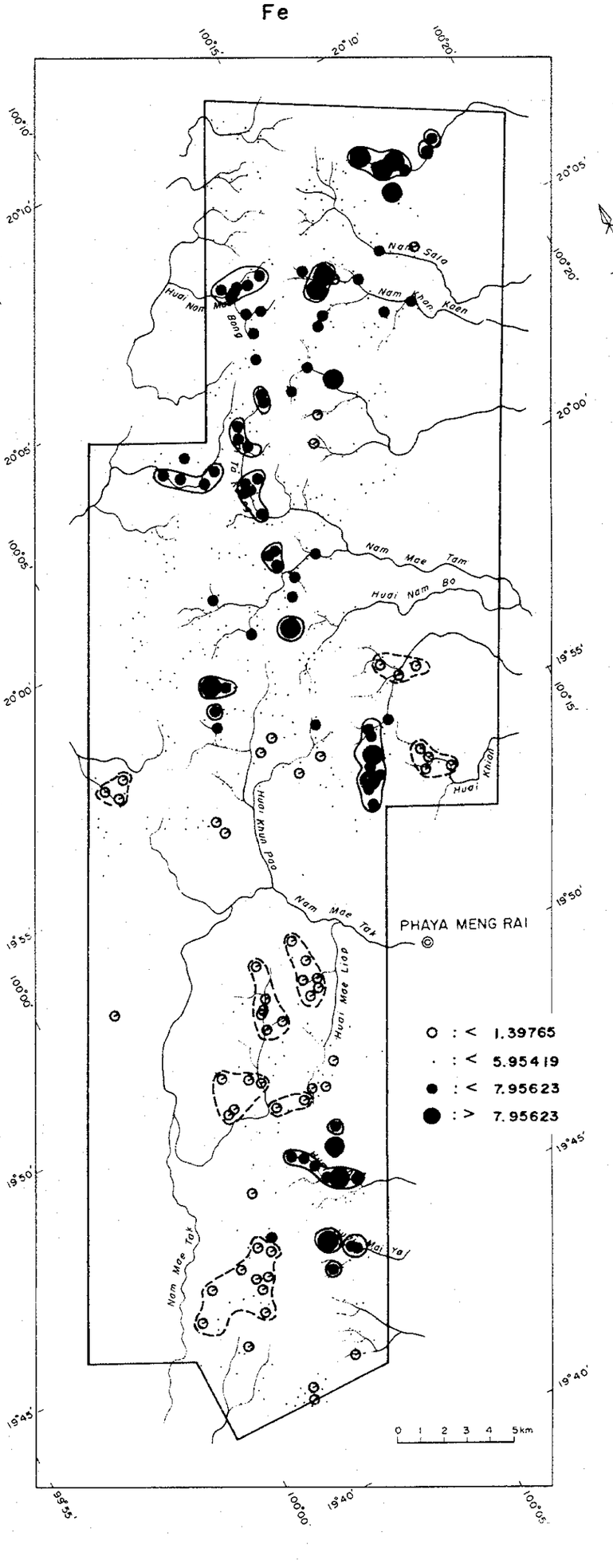
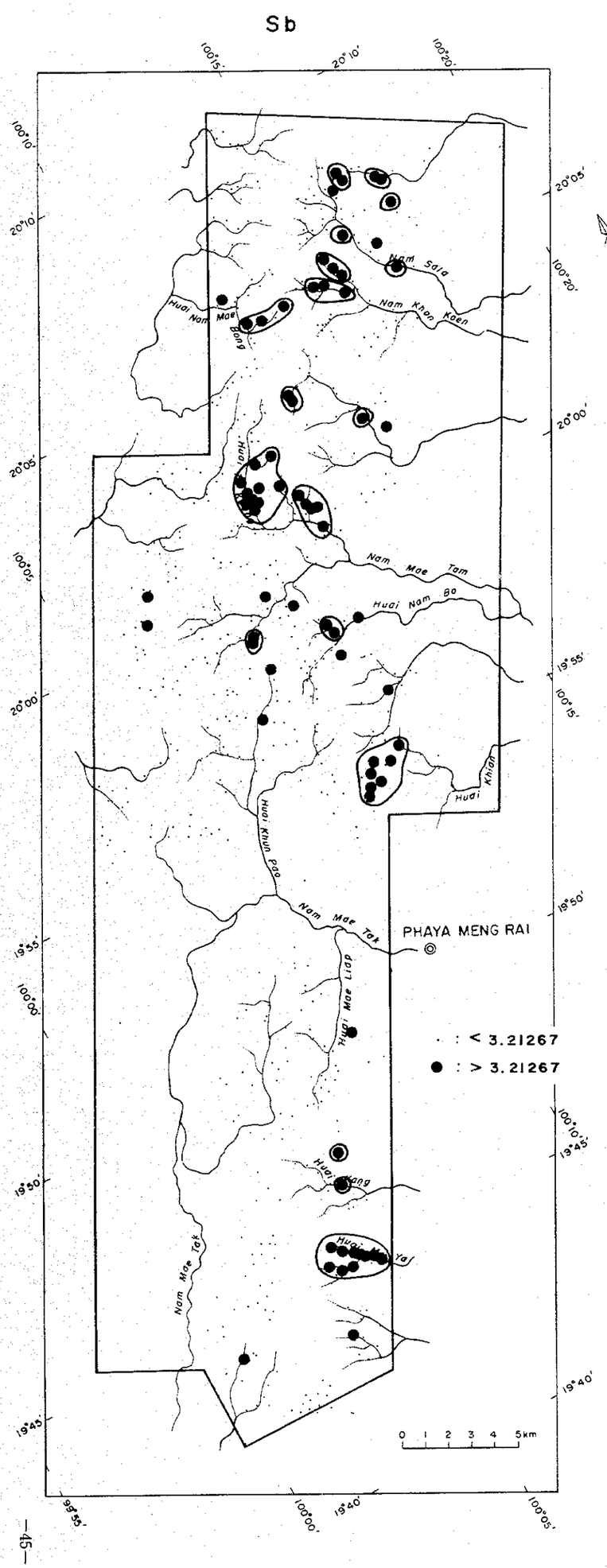


Fig.12 Geochemical anomaly map of stream sediments in Chiang Khong area (5)



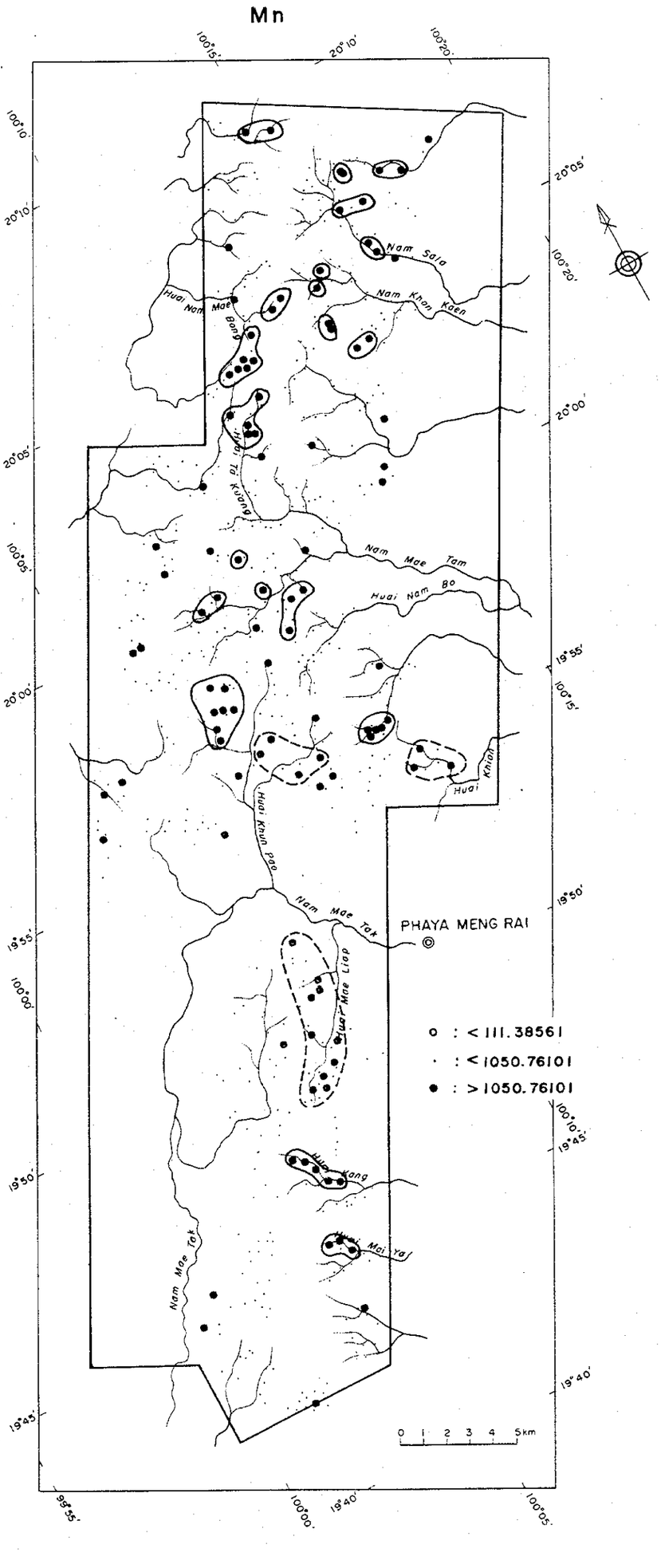


Fig.12 Geochemical anomaly map of stream sediments in Chiang Khong area (6)

result in the Chiang Khong area, was obtained here.

[Ag]

99% of the analytical values are detected limited values. Excluding the limited value of 0.2ppm, these are only three samples with higher values. Highest value of 1.2ppm is distributed in Nam Sala.

[Cu]

The high anomaly zones for copper are distributed in the north and south of the area. The anomaly zones in the north are seen in the upper reaches of Nam Thung Lo and Huai Nam Mae Bong which overlap with the gold anomaly zone, Nam Khon Kaen tributary and Huai Ta Khuan. They are all seen near faults. The anomaly zones in the south are those distributed in the vicinity of basalt and those distributed overlapping with anomalies of gold in slate, as in Huai Mae Liap southwest of Phaya Men Rai town.

Low anomaly zones for copper are observed in the vicinity of the north and central granite body and in the sedimentary rocks and tuff distributed zone northeast of Phaya Men Rai.

[Pb]

High anomaly for lead are scattered and there is no large high anomaly zone, but a high anomaly zone is formed south of the north granite body. On the other hand, low anomaly zones are distributed around the center and south granite bodies.

[Zn]

Distribution of high anomaly for zinc conforms well with distribution of high anomaly for copper. The low anomaly zones conform to the tuff distribution zone in the north, to the distribution of Permian sedimentary rocks and on the west side of granite bodies in the center to south of the area.

[Hg]

The anomaly distribution for mercury closely resembles the gold anomaly, but there is no anomaly in the central nortern region and in the south of the area. Also, anomalies are observed in the vicinity of new andesite of Jurassic age.

[As]

The anomaly zone for arsenic is concentrated on the boundary between mountainous region and the plains in the north of the area and is located outside the high anomaly zones for gold, copper, zinc and other elements. Adversely, low anomaly zones for arsenic are distributed along the fault where high anomaly zones for gold, copper, zinc, iron, etc. are distributed. In addition to showing high anomaly zones which conform to the high anomaly zones for copper and zinc around the south granite body, an extremely high anomaly zone is evident in Huai Tum Nua in the southernmost part of the area..

Low anomaly zones in the south are widely distributed around and to east of the central granite body.

[Fe]

High anomaly zones for iron are distributed over samll area and conform to the anomaly zones for copper and zinc in Nam Thung Lo, Nam Khon Kean tributaries and around basalt in the south. In

addition, anomaly zones are evident in Nam Pomg Ngae in the north of area, along the fault in the central northern region and in the andesite zone north of Phaya Men Rai.

The low anoamaly zones resemble low anomaly zones for zinc.

[S]

The anomaly zones for sulphur are observed in a NE-SW direction along the fault in the upper reaches of Nam Sala in the north, also the zones conform to the anoamly zones of goldand copper in Huai Mae Liap southwest of Phaya Men Rai.

In the central region, anomalies are scattered here and there.

[W]

95% of the samples are detected limit values or below. The highest value is only 40ppm. Anomalies are scattered here and there and distribution resenbles that of iron.

[Sb]

Distribution of the antimony anomaly zones resembles the iron high anomaly zone, but the range is wider than for iron.

[Mn]

Close conformation to the behavior of iron is observed.

4. Principal componets analysis

The principal componets analysis was carried out with regard to correlative matrices obtained from the logarithum values of the geochemical data. The results are shown in Table 7.

Eigenvalues are over 1.00 up to the fifth component and the cumlative contribution rate is 69%. Scores distribution map up to fifth component is shown in Fig 13.

Table 7 Results of principal components analysis in Chiang Khong area

Principal componet	Eigen-value	Contribu-tion rate%	Cumulaive%	Factor loading	Z-01	Z-02	Z-03	Z-04	Z-05
Z-01	3.6182	30.1514	30.1514	Fe	0.9120	-0.1095	-0.1225	-0.0524	-0.0131
Z-02	1.3631	11.3589	41.5102	Zn	0.8690	-0.0642	0.0062	0.2183	-0.0547
Z-03	1.2681	10.5678	52.0781	Mn	0.8081	-0.1119	-0.0693	-0.0677	0.1371
Z-04	1.0844	9.0363	61.1144	Cu	0.6497	0.0513	-0.0932	0.3142	-0.5119
Z-05	1.0583	8.8190	69.9334	Pb	0.5950	-0.1822	0.0663	-0.1873	0.5434
Z-06	0.8840	7.3668	77.3002	W	0.4647	-0.4448	-0.1869	-0.1767	-0.2292
Z-07	0.7433	6.1938	83.4940	Sb	0.3213	0.7325	-0.1340	-0.1567	0.0996
Z-08	0.6406	5.3385	88.8325	As	0.2386	0.6660	-0.2314	-0.2764	-0.1450
Z-09	0.5705	4.7545	93.5870	Ag	0.0597	-0.1111	0.6667	-0.3470	-0.0365
Z-10	0.4129	3.4407	97.0277	Au	0.1691	0.0564	0.4990	-0.4430	-0.4950
Z-11	0.2135	1.7789	98.8066	S	0.1465	0.2216	0.5210	0.6672	-0.0433
Z-12	0.1432	1.1934	100.0000	Hg	0.4152	0.2366	0.4048	0.0394	0.3837

First component (Z-1):

The factor loadings for Fe, Zn, Mn, Cu, Pb, W and Hg are large, suggesting that they reflect the

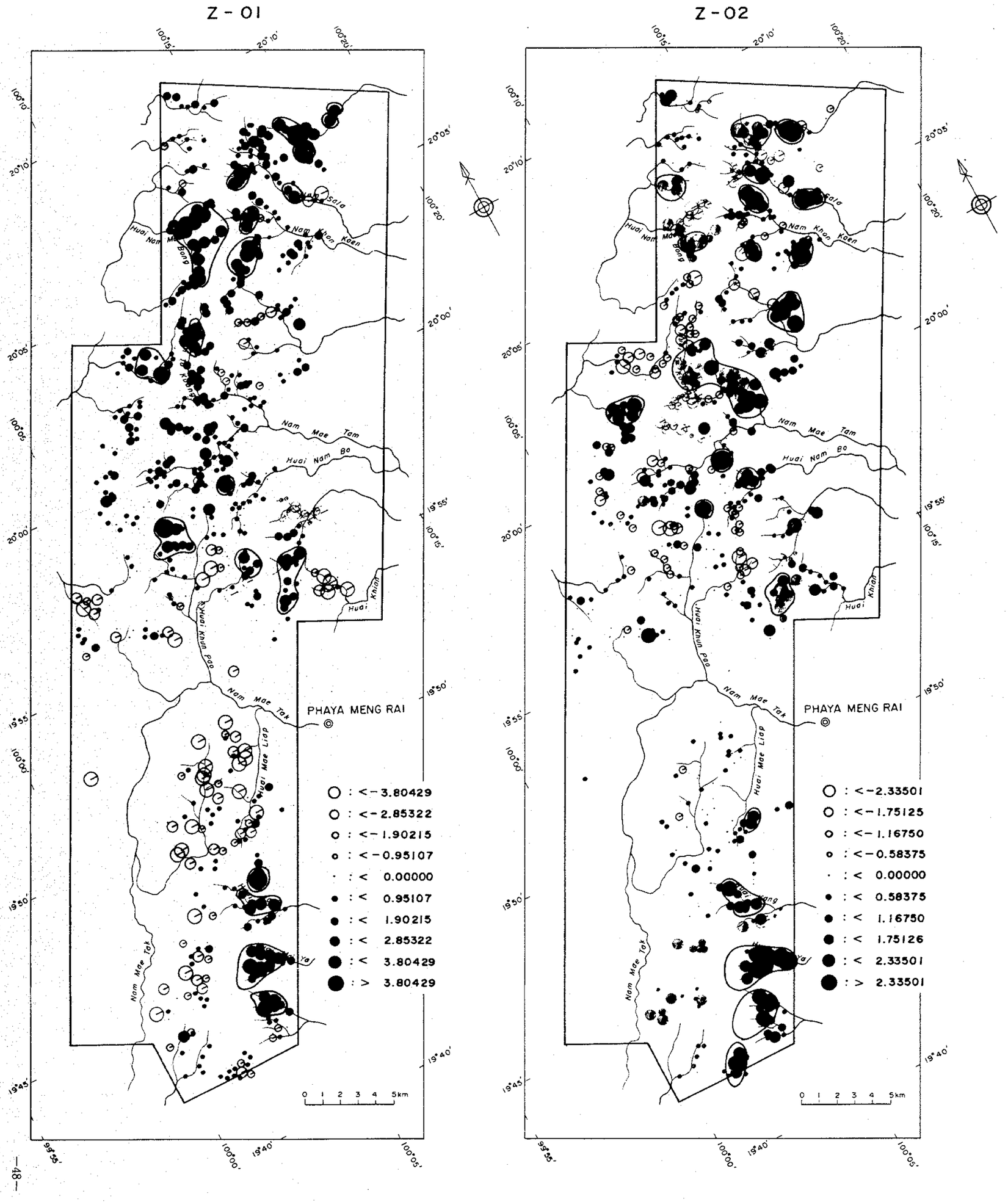
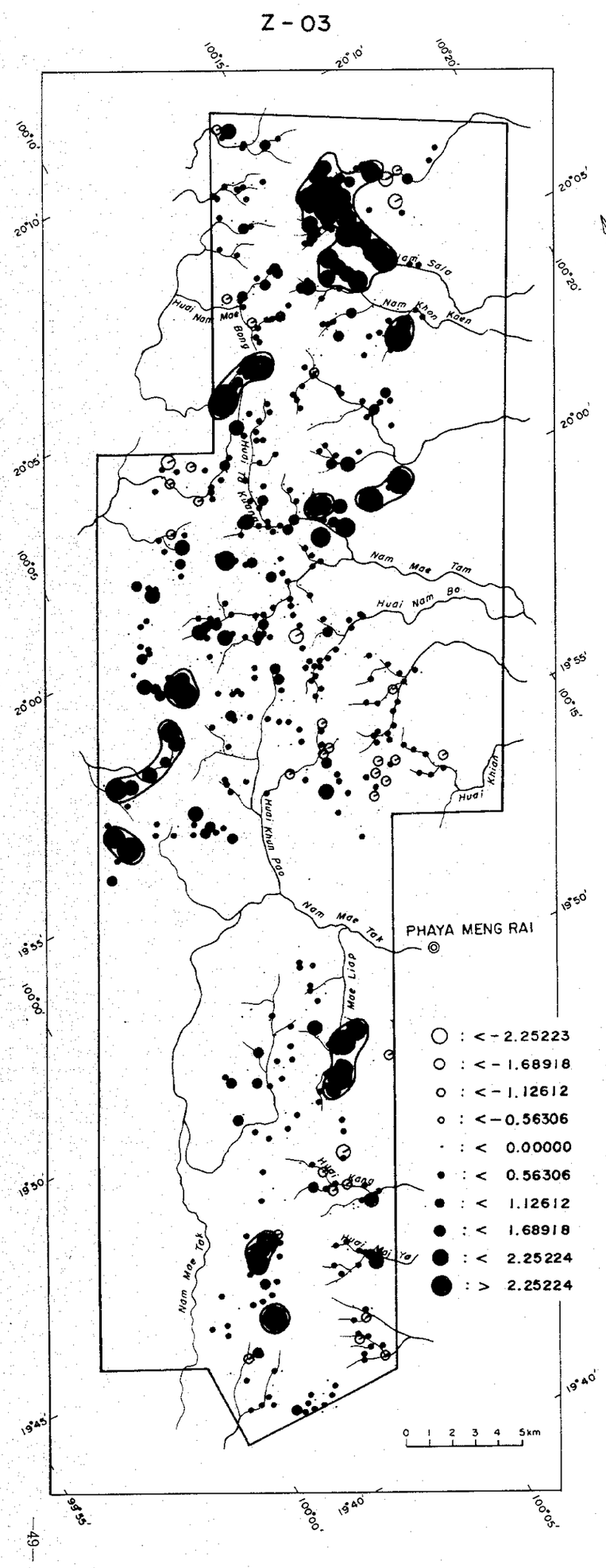


Fig. 13 Scores of principal components analysis in Chiang Khong area (1)



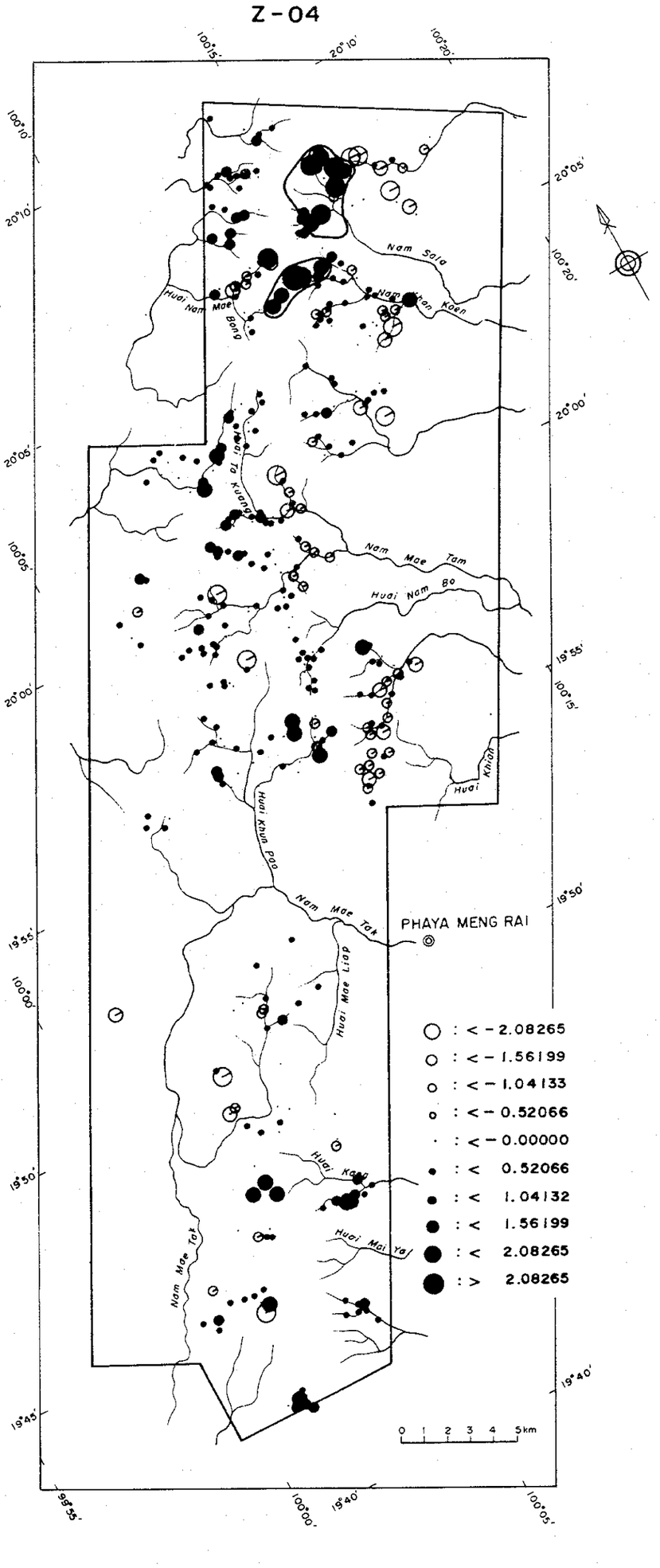


Fig.13 Scores of principal components analysis in Chiang Khong area (2)

Z - 05

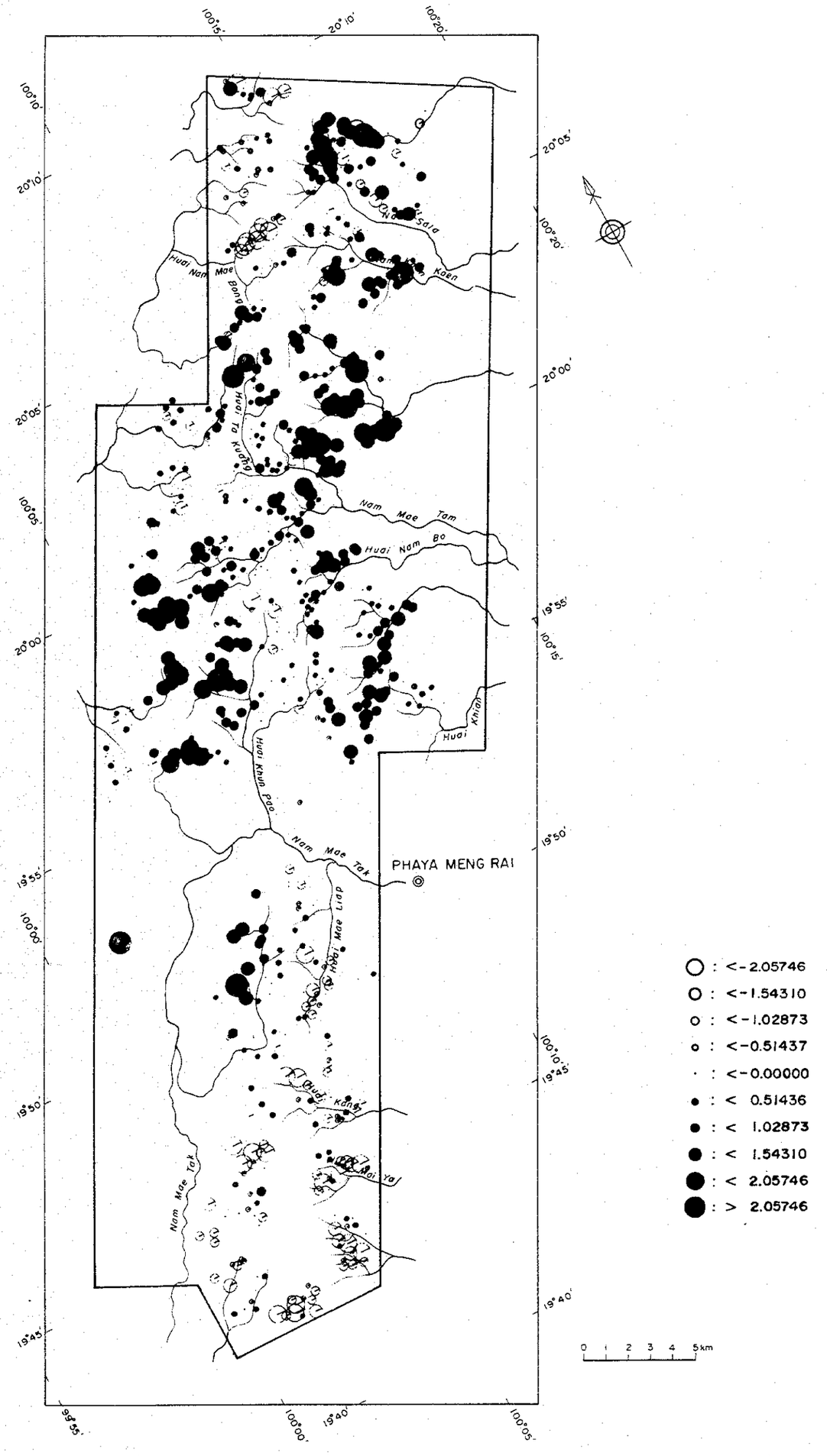


Fig.13 Scores of principal components analysis in Chiang Khong area (3)

existance of base metals. High Score zones for Z-1 are seen around the alteration zone and along the fault in the north and is thought to indicate base metals mineralization. In the South high scores are distributed to the east of the south granite body.

Scond componet (Z-2):

The factor loadings for As and Sb are large, suggesting the existance of both elements in stream sediments. They are distributed in the vicinity of Z-1 in yhe north, overlapping in some parts. Z-2 shows higher scores than Z-1 in high alutitudes. This may indicate the mineralization halos concerning to Z-1.

The highest score zone is seen at abovestream and downstream around andesite lava in the upper reaches of Huai Mae Tam of the central region.

High score zones in the south resemble that of Z-1, but the highest score zone is concentrated futher downstream than the Z-1 high score zone.

Third component (Z-3):

The factor loadings for Ag, S, Au and Hg are high. Considering that Ag has low, it is thought to indicate gold mineralization and its halos. In the north of the area, in addition to high score zone overlapping thealteration zone and fauts in the upper reaches of Huai Sala, there is high score in the lower tributaries of Huai Khon Kaen and along the faults which continues to the southwest of the alteration zone. High Score zone is also seen in the area from Nam Mae Tam to the middle reaches of Nam So. In central region, high scores are evident on the boundary with sedimentary rocks, west of south granite body. This high score zone is almost dependent on the S anomaly values, Ture high score zones of Z-1 are distributed in the upper reaches of huai Liap and Huai Pla, west of the south granite body.

Fourth component (Z-4):

The S factor loading is high, suggesting the sulphide minerals mineralization. It conforms to the high score zone of Z-3, but has a smaller range.

Fifth componet (Z-5):

The Positive factor loading for Pb is High and the negative factor loadings for Cu and Au are high. The high scores for Z-5 are distributed in the nortern half of the area. They mostly conform to the Permo-Triassic tuff and tuff breccia and the factors are thought t oindicate igneous activity in Permian age.

1-7 Considerations

The Chiang Khong area is composed of Permian sedimentary rock such as sandstone (PRs), mudstone (PRm),conglomerate (PRc) and limestone (PRl), Permo-Triassic andesitic and rhyolitic lava (PTa, PTr), tuff (PTt) and tuff breccia (PTb), Triassic granite (Gr), Jurassic andesite lava (ms2), red siltstone and sandstone (ms3) of the Jurassic, Pliocene siltstone (ng), and Plio-Pleistocene basalt (Ba).

Four periods of igneous activity are known: andesite and rhyolite in the Permo-Triassic, granite in the Triassic, andesite in the Jurrssic and basalt in Plio-Pleistocene age.

The geologic structure shows the formation of a mountainous region extending NE-SW overall,

and there is an evident tendency for the distribution of stratum to continue virtually in harmony with this direction.

The strikes and dips of Permian sedimentary rocks show steep dip and a large syncline structure, with the center of moutainous range as its axis.

Permo-Triassic volcanic rock is accompanied by tuffs and covers the Permian system with unconformity. It shows distribution in two parallel zones running NE-SW.

Permo-Triassic tuff, accompanied by dome-shaped andesite and rhyolite, is prevalent in the northeast of the Chiang Khong area, and it shows a monoclinal structure on the east side in this region.

In addition to the faults and lineaments of the Chiang Khong area which have developed in a NE-SW direction along the synclinal axis of sedimentary rock of the Permian, there is marked faults which run obliequely in an ENE-WSW direction. These faults and lineaments are well developed in the north than in the center of the Chiang Khong area. Distribution of Jurassic andesite and alteration zones in the north is controlled by these fault systems.

Granites intrude virtually into the axis of the synclinal structure, and the major axis direction of the rock body conforms to the NE-SW direction of the area, but the line linking the centers of the three rock bodies runs obliquely to this direction, showing a NNE-SSW direction, and it is in echelon.

Whereas the granite is exposed in the southern half of the area, no distribution of granite is evident at the northern tip. It is known that small granite bodies have intruded to the north of the Chiang Khong area and the existence of granite bodies is assumed below the northern tip of the area. It is assumed from this that the N-S geologic structure of the Chiang Khong area shows that the southern half rose considerably and plunged to the north which was pared away.

There are no mines with a productive record in the Chiang Khong area. According to information from a local owner of mining rights, there are two occurrence for copper and one for gold. The gold occurrence is located on the boundary with sedimentary rock at the southernmost part of the central granite body. The owner once discovered gold flake with 5 to 6 milieters in diameter by panning. A geochemical data of Au=16ppb was obtained from a stream sediment. One of copper occurrence is locted on the Doi Ngaem mountain ridge, west of Ban Bo Seang. There is a white sandstone of Permian age. Seams of green copper are evident in the massive sandstone and a grade of Cu=1.57% was obtained from the sample.

Tuffceous rocks in the Chiang Khong area have undrgone marked white argillization, but it is mostly thought to have been kaolinnized due to tropical weathering.

Nevertheless, a white argillized alteration zone acoompanying limonite-quartz vein is senn on the mountain pass of the highway which traverses the northern part of the Chiang Khong area. Gold flake was discovered by panning in two places in rivers along the alteration zone. It is likely that this alteration zone is connected with gold mineralization. The alteration zone covers 3km wide by 12km long along the fault zone which runs in a NE-SW direction.

There are no very clear mineral occurrence in the south of the area, but intense argillized alteration and quartz vein are seen inaprts of Permo-Triassic tuff in southeast of the area, and quartz veins

have developed in Permian slate.

Hornfels and small-scale skarn is evident around the granite bodies, but it is accompanied by dissemination of only a small amount of pyrite, pyrrhotite and chalcopyrite.

From the results of geochemical prospenting, the high score zone of the third component (Z-3) which shows Au-Hg-S minaralization and its halo, extends over a wide area, overlapping with the argillized zone along the faults around the upper reaches of Nam Sala in the north. The Au anomaly in Nam Sala ranges from 30 to 770ppb. In addition, the high score zone is also found along the southextention of the fault zone and from Nam Mae Tam to Nam So.

In the south, high score zones for Z-3 are also widely distributed in Huai Mae Liap, southwest of Phaya Men Rai. Other high score zones are not very large with expection of Huai Pla in the suthwest of the area. Almost of these reflect the S anomaly without being accompanied by Au, Hg anomaly of single element.

The high score zone of first component which indicates base metals mineralization is distributed in harmony with the alteration zone and faults in the north. It surrounds the high score zone for Z-3 in the upper reaches of Huai Sala. With the exception of high score zones involving Fe anomaly, the potential area of Cu and Zn mineralization is limited to the area from Huai Thung Lo to Huai Kong Kean tributary in the southwest of alteration zone.

In the southeast of the area, A high score zone is observed on the east side of the granite body.

Thus, in Chiang Khong area, the indications of gold and base metal mineralization obtained by geochemical prospecting show a different distribution although they overlap in places.

These mineralizations occur with Permo-Triassic volcanic rocks and in parts, Permian sedimentary rocks. It is likely that in the north, mineralization occuered due to the activity of Triassic andesite, in the south in connection with Triassic granite.

Judging from the above, the promising regions of mineral deposits in the Chiang Khong area are the upper reaches of Huai Sala and Huai Mae Liap regions for gold deposits, and Nam Mae Bong and Huai Mai ya regions for base metal deposits (Fig. 14)

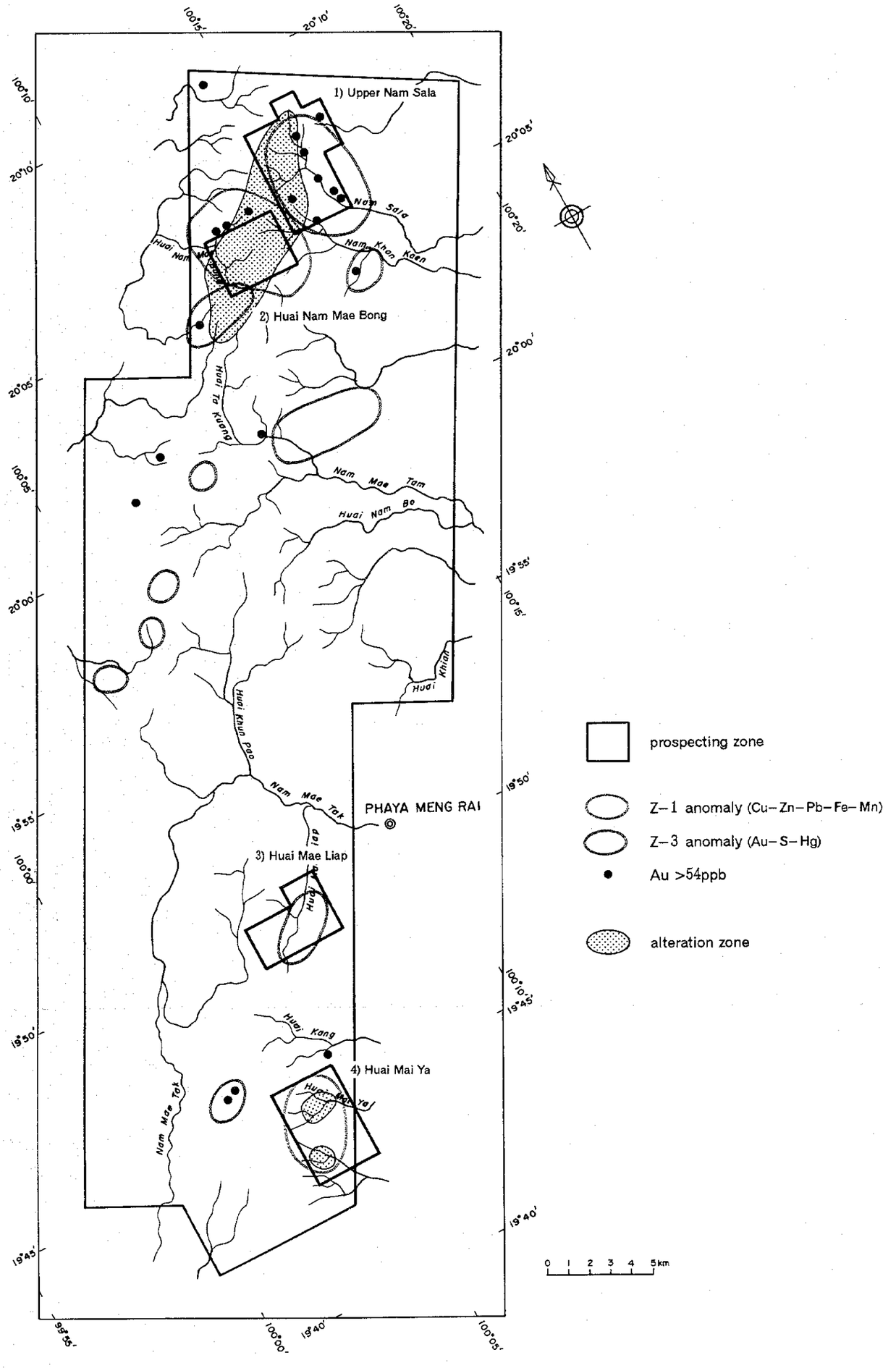


Fig.14 Interpretation map of Chiang Khong area

CHAPTER 2 DOI CHONG AREA

2-1 General Geology

The geology of the Doi Chong area is made up, from below, of Carbono-Siluro-Devonian Mae Tha Group and Donchai Group, Permian Ratburi Group Kiu Lom Formation (P1), Pha Huat Formation (P2) and Huai Thak Formation (P3), Permo-Triassic Volcanic Formation (PTR), Triassic Lampang Group Hong Hoi Formation (TR) and Triassic intrusive granite (Gr) and diorite (Di), etc.The survey area can be broadly classified geologically into three regions: a steep mountainous region which accounts for the main part of the survey area, gently-sloping hilly terrain distributed in the north, and flat land seen in the southernmost part.

Of these three regions, the hilly region in the north is thought to correspond to Hong Hoi Formation of the Triassic Lampang Group, and the flat land at the southern tip to the alluvium.

According to the geologic map, scale 1:250,000, (DMR, 1985), Silurian-Devonian strata are widely distributed in the mountainous region which forms the main part of the survey area. However, judging from the fact that Middle Permian fossils have been discovered in the limestone in the survey area, and from the characteristics of the rockfacies, for this survey Permian system is taken to be widely distributed in these zones, and distribution of Carbono-Siluro-Devonian strata is limited to the southwest of the survey area which has undergone relatively strong metamorphism and deformation. Also, distribution of Permo-Triassic volcanic rock is limited to the southeastern tip of the survey area.

There are many relatively small-scale granite and diorite bodies. The largest has a size of around 2 x 8km and is found in the mountainous region between Huai Mae Thot and Huai Mae Tia. It has been confirmed that sedimentary rock around the granite has frequently undergone contact metamorphism, showing that the granite is intrusive. It is assumed that the intrusive direction of the granite is N-S or NW-SE, and this harmonizes with the geologic structure of the surrounding sedimentary rock and the direction of the faults. The age of the granite in the survey area is not clear, but judging from the fact that the granite intruded into Permo-Triassic strata and that the granite in the environs of the survey area has been reported to have an age of 205 to 236Ma by Rb-Sr radiometric dating, it is thought to belong to the Later Triassic. However, the order of intrusion of the granite and diorite is not clear.

The geologic map and schematic geologic column of the Doi Chong area are shown in Figs. 15 and 16.

2-2 Detailed Geology

2-2-1 Carbono-Siluro-Devonian rocks (CDS)

The Carbono-Siluro-Devonian in the survey area is composed of crystalline schist (CDSs)

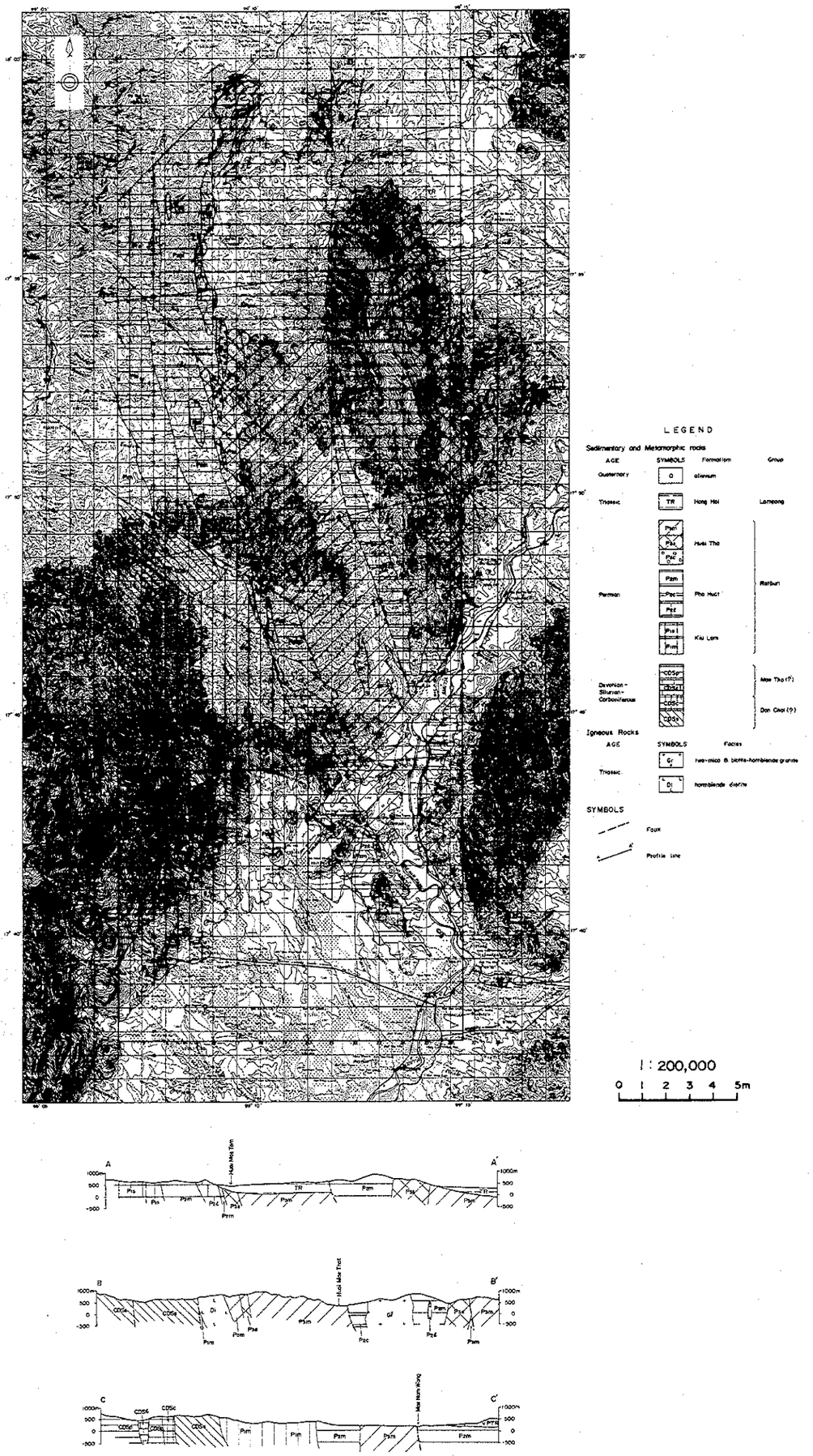


Fig.15 Geologic map in Doi Chong area

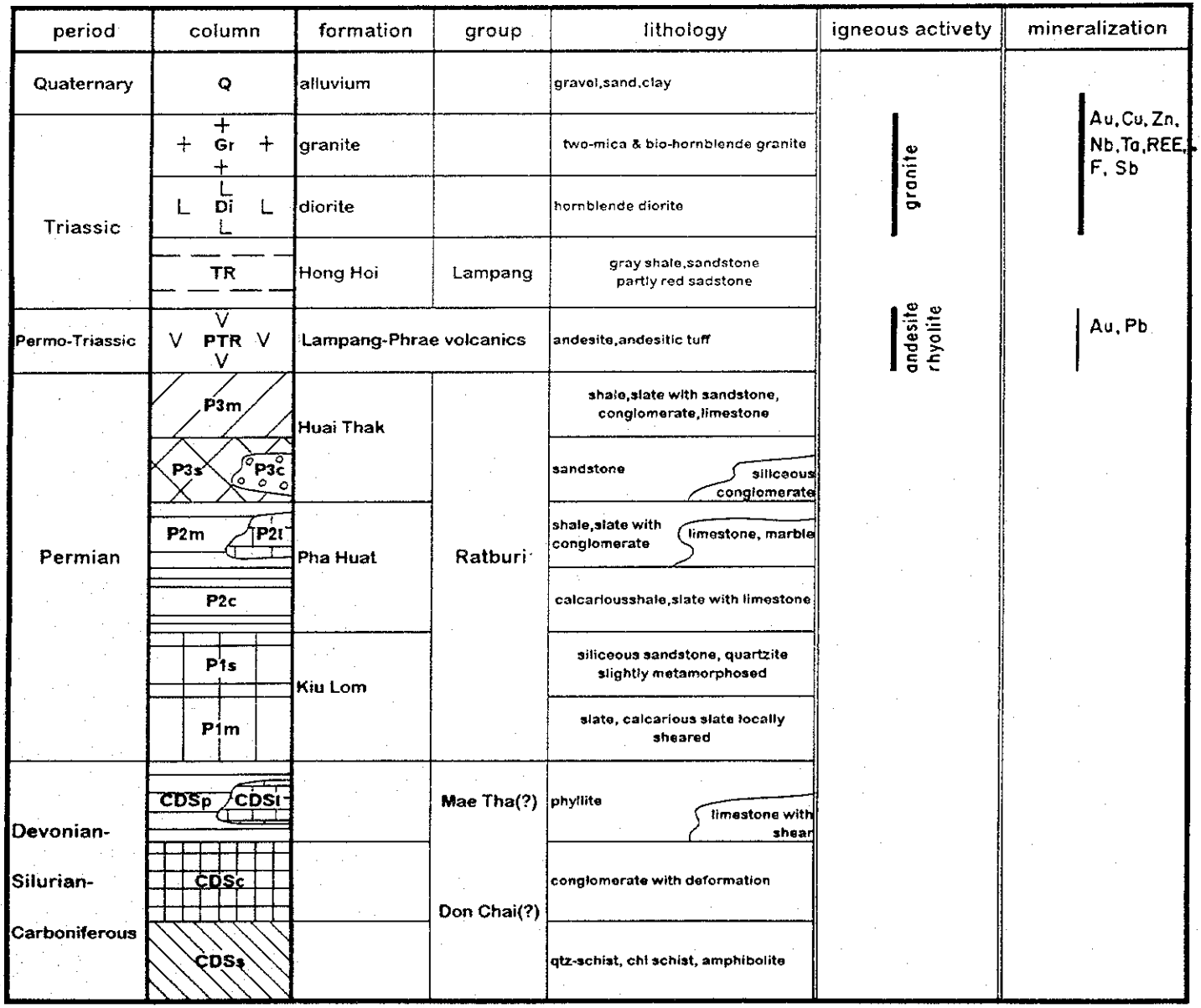


Fig.16 Schematic geologic column in Doi Chong area

such as quartz-mica schist, quartzite and chlorite-schist, conglomerate (CDSc) which has undergone deformation, phyllite (CDSp) and limestone (CDSl). From the characteristics of the rockfacies, it can be correlated to Carboniferous Mae Tha group or Siluro-Devonian Donchai Group.

This stratum is distributed on the west of the Permian and is thought to have a discordant relationship, or in some part s a fault relationship, with the Permian. Each rockfacies is well exposed in the middle to upper reaches of Huai Mae Kaeng and in the upper reaches of Huai Mae Toen, etc., but the vertical relationship between each is not clear. Moreover, each rockfacies lacks continuity and is thought to have been severed by faults running NW-SE.

All the rockfacies have developed schistosity and cleavage planes and the structure of the primary bedding plane is not clear. The strike of the schistosity and cleavage planes is concentrated in a NNE-SSE ' N-S direction. Both an east and west dip are evident and they are both high-angle.

Two types of crystalline schist (CDSs) are mainly seen, siliceous schist and basic schist. The former includes quartz-mica schist, quartz schist, etc. and is intercalated with seams of pelitic schist, limestone, meta-conglomerate and chlorite-schist. The quartz-mica schist and quartz schist show a grayish white color and a schistose plane has developed due to muscovite. Moreover, quartz veins in echelon form are frequently observed.

The basic schist includes chlorite-schist, amphibole, etc. and the primary rock is taken to be basic tuff or massive bas ic lava, etc. It displays a pale green to green color and sometimes contains pyrite.

The conglomerate (CDSc) includes gravels of limestone and quartz with a diameter of around 5 to 15cm. It has undergone complete deformation, mica has formed on the matrix and a schistose plane has developed. Also, the gravels extend in the direction of the schistose plane. Grading structure by the gravels is very occasionally seen, and oblique crossing of the sedimentary structure and schistose plane is observed.

The phyllite (CDSp) shows a grayish-white to white color and is accompanied by muscovite, etc. A planar structure has developed and peels off easily like leaves. On rare occasions it is intercalated with extremely fine sandstone and limestone.

The limestone (CDSl) is distributed as small rock bodies in the phyllite or quartz-mica schist. It displays a white to grayish-white color and is crystalline. It has undergone complete deformation, and some has a weak planar structure and some shows a gravelly form. The limestone distributed in this stratum is characterized by having undergone deformation and by a total lack of Fusulinidae, and this distinguishes it from Permian limestone.

2-2-2 Permian Ratburi Group

Ratburi Group can be classified generally into Kiu Lom Formation (P1), Pha Huat Formation (P2) and Huai Thak Formation (P3). Kiu Lom Formation consists mainly of mudstone, shale and sandstone and is characterized by having undergone shearing deformation. Pha Huat Formation is accompanied by many limestone bodies and is composed of shale, calcareous shale. Huai That Formation consists of shale and sandstone with limestone seams.

The rockfacies of Ratburi Group in the survey area are mainly composed of shale, slate, sandstone, conglomerate, calcareous shale and limestone, etc. These rockfacies have changed gradually, making classification into the strata mentioned above difficult, but the limestone bodies and shale surrounding them, distributed almost continuously arranged in zones from the southeast tip to the northwest tip of the survey area, correlate to Pha Huat Formation. Also, the shale stratum distributed to the west of the Pha Huat Formation, which is accompanied by a sandstone layer and phyllite and has undergone weak metamorphism, is thought to correlate to Kiu Lom Formation, and the stratum distributed to the east, which consists mainly of shale, is thought to correlate to Huai Thak Formation.

1. Kiu Lom Formation (P1)

This formation is elongated in a NNW-SSE direction on the west side of the survey area. It can be classified broadly into a sandstone stratum (P1s) and slate stratum (P1m). The distribution zone of each stratum is limited by a fault extending southwest from Huai Ping. In other words, the sandstone stratum is prevalent in the north of the survey area, for example in Huai Ping and Huai Mae Bon, and hardly continues at all south of the fault. On the other hand, the slate stratum is widely distributed on the south side of the fault, for example in the Huai Mae Toen basin. The sandstone stratum (P1s) has completely undergone weak metaphormism and is composed of meta-sandstone, quartz schist, quartz, siliceous phyllite, etc. All the rockfacies show colors from grayish-white to pale green, are fine to medium-grained, siliceous, and rich in quartz-muscovite. A weak schistose plane has been formed running NNW-SSE. Also, a quartz vein about 1 to 5cm wide is seen virtually parallel to the schistose plane. The slate stratum (P1m) is mainly composed of pale gray to white shale-slate. It has undergone shearing in uneven quality and phyllite is frequently seen. It is sometimes intercalated with medium to coarse sandstone or calcareous shale, and in rare cases it contains limestone about 40cm wide. The cleavage planes run NNE-SSW to NW-SE.

2. Pha Huat Formation (P2)

This formation is characterized by a shale stratum (P2m) which contains a large number of limestone bodies. This is seen in two regions, virtually in the center of the survey area and on the east of Huai Mae Thot, and both run in a NNW-SSE direction. On the east side of Huai Mae Thot, there are continuous traces of calcareous shale along Huai Mae Thot. This calcareous shale is thought to form the lower stratum of the formation and in this report it is classified as calcareous

shale stratum (P2c).

The shale of the shale stratum (P2m) shows a gray to dark gray color. Generally it has a weak cleavage plane, but the planar structure has developed in the vicinity of the fault and slate, phyllite, etc. are also seen. It is intercalated with calcareous sandstone, tuff sandstone, red shale. Also, conglomerate containing a large quantity of quartz gravels is seen in this layer. The conglomerate shows a grayish-white or red color and is composed of quartz stones measuring 5 or 6cm in diameter and siliceous matrix.

The largest limestone body (P2l) in the shale is around 1 x 2km, and with the exception of the bodies in the vicinity of the fault along Mae Nam Wang, they extend in the direction of the shale. The limestone shows a color from colorless to grayish-white, and pale green limestone is also seen. The limestone in this formation is characterized by containing a large quantity of Fusulinidae, and Middle Permian fossils have been found in the limestone bodies around where Mae Nam Wang and Huai Mae Pong converge.

The calcareous shale stratum (P2c) is mainly composed of gray shale and grayish-white calcareous shale, with frequent alternation of strata at intervals of 2 ` 5cm. It is intercalated with sandstone, limestone and conglomerate containing limestone gravel. Recrystallization of sandstone, formation of green epidote in the calcareous shale, etc. due to thermal metamorphism are seen in the vicinity of the granite bodies.

3. Huai Thak Formation (P3)

This formation mainly consists of shale and slate accompanied by sandstone and conglomerate. Sandstone and conglomerate prevail in the lower part of the formation, and although distribution disappears in the south of the survey area, they can be traced relatively continuously. In this report, they are treated as sandstone strata (P3s) and are distinguished from the overlying shale strata (P3m) in which shale and sandstone are dominant. The cleavage plane and bedding plane run mainly NNW-SSE to N-S. However, the bedding plane inside the sandstone rockfacies crosses them obliquely and in some cases shows a NE-SW direction and is thought to have preserved a primary sedimentary structure.

The shale stratum is mainly composed of dark gray shale and slate shale and is intercalated with tuff shale, arkose sandstone, calcareous conglomerate, etc. Veins of quartz and aplite are seen virtually parallel to the cleavage plane in the shale and intrusion of small-scale granite bodies is also apparent in the lower basin of Huai Mae Thot.

The sandstone stratum is composed of medium to coarse sandstone and conglomerate and in some cases is intercalated with slate or stratified chert. The sandstone displays a gray to grayish-white color and frequently contains limestone lens. The conglomerate displays a dark gray color and contains a large quantity of quartz gravels 3 to 5cm in diameter. The matrix is extremely siliceous and is accompanied by many quartz veins.

2-2-3 Lampang-Phrae Volcanic Formation (PTR)

This formation is widely distributed in the mountainous region on the left bank of Mae Nam Wang, but only slight distribution is seen at the southeast tip of the survey area. It is thought to have unconformably covered the lower Permian system. The rockfacies are andesite, pale green to greenish gray tuff, tuffceous shale, etc. Intrusive bodies of granite are seen in this formation and andesite around the granite has undergone slight thermal metamorphism.

2-2-4 Hong Hoi Formation (TR)

This formation is widely distributed in the north of the survey area and has formed gently-sloping basins and hilly regions. The rockfacies consists of sandstone, shale and alternation of sandstone and shale and sandstone is dominant. It has a generally unconformable relationship with the underlying Permian, but is thought to have been bordered by a reverse fault running N-S in the Huai Mae Haet basin. Both the bedding plane and the cleavage plane run NNE-SSW, show a high-angle western dip and resemble the geologic structure of the Carbono-Siluro-Devonian and Permian. The sandstone is medium to coarse grained and generally shows a gray to grayish-white color, but red to dark brown is also seen. In many cases it has undergone heavy weathering and is rather soft. The shale displays a gray to pale gray color. Some shows a fold structure on a NW-SE axis. Intrusive granite rocks are seen in this formation, but no thermal effects of the rocks surrounding the granite is evident.

2-2-5 Intrusive rocks

Nine bodies of intrusive rock of varying size are seen in the survey area. Only one of these is dioritic, but most of the intrusive rocks are granite.

1. Granite (Gr)

The intrusive direction of the granite is mainly N-S or NW-SE and is thought to have been controlled by the surrounding geologic structure or the direction of the fault. The intruded horizon is Permian, Permo-Triassic or Triassic and it has caused contact metamorphism of the Permian and Permo-Triassic. Intrusion has occurred to a large extent in the vicinity of the fault, for example in the Huai Mae Thot basin.

The rockfacies are biotite granite, biotite-muscovite granite, muscovite granite, muscovite granite porphyry, etc. and are generally leucocratic. Fine, leucocratic rock containing hardly any colored minerals is also seen, especially in the periphery of the rock bodies. The susceptibility of the granite rocks is low, showing a value of 0.04 to 0.06 x 10^{-3} S.I. unit, and they are thought to belong to the ilmenite series.

2. Diorite (Di)

Diorite is distributed in the uppermost reaches of Huai Mae Toen. It is composed of diorite

containing amphibole and pyroxene, and quartz-diorite, and in many parts it has undergone cataclastic action. In addition to a wide-ranging silicified zone that has formed in the environs of the rock bodies, the rock bodies themselves have undergone dissemination of molybdenite, pentlandite, etc.

2-2-6 Alluvial deposits (Q)

This is distributed in the Mae Nam Wang basin and on the flat land in the south of the survey area. It is composed of unconsolidated gravel and sand.

2-3 Geologic Structure

There are assumed to be faults running NW-SE, N-S and NE-SW in the survey area. The direction of the bedding and cleavage planes of the strata in the vicinity of the NE-SW fault along Mae Nam Wang and the NW-SE fault in the upper reaches of Huai Mae Toen inclines to the direction of the fault. It is assumed that in the case of the other faults too, taking the fault as the boundary, the geology is not continuous. In particular, the faults along the Huai Mae Thot running NNW-SSE to N-S are assumed to be relatively large-scale reverse faults.

The geologic structure of the Carbono-Siluro-Devonian and Permian on the whole runs in a NNW-SSE direction and the upper stratum overlaps facing northeast. Also, Permo-Triassic volcanic rock and Triassic system are distributed covering them unconformably. However, according to the fault along Huai Mae Thot, it is thought that the eastern side of the fault has risen relatively, and with the fault as the boundary, the subordinate Permian layer is exposed.

Schistosity and cleavage planes of varying degrees are seen in most of the sedimentary rock in the survey area, and on the whole the planar structure runs NNW-SSE to N-S. It is known that the environs of the survey area underwent wide-ranging deformation in Carboniferous time and there is marked development of schistose planes, phyllitization, conglomerate deformation in the Carbono-Siluro-Devonian. The planar structure that is seen in the Permian and Triassic is well developed in the vicinity of the faults, and in addition it has also developed around the granite bodies, accompanied by hornfelsization.

2-4 Geochemical characteristics of igneous rock

Whole rock analysis of 14 samples taken in the Doi Chong area was carried out. The samples consisted of 7 samples of granite, 4 of granite porphyry, 1 of diorite and 1 of quartz diorite. 2 samples of granite, 1 of granite porphyry, and 2 of Tak batholith distributed in the southeast of the Doi Chong area, that were collected in the preliminary survey, are also given as reference values. The analytical values and norm component values are shown in Appendix 11.

As can be seen in Fig. 17, with the exception of one sample of diorite and one of granite

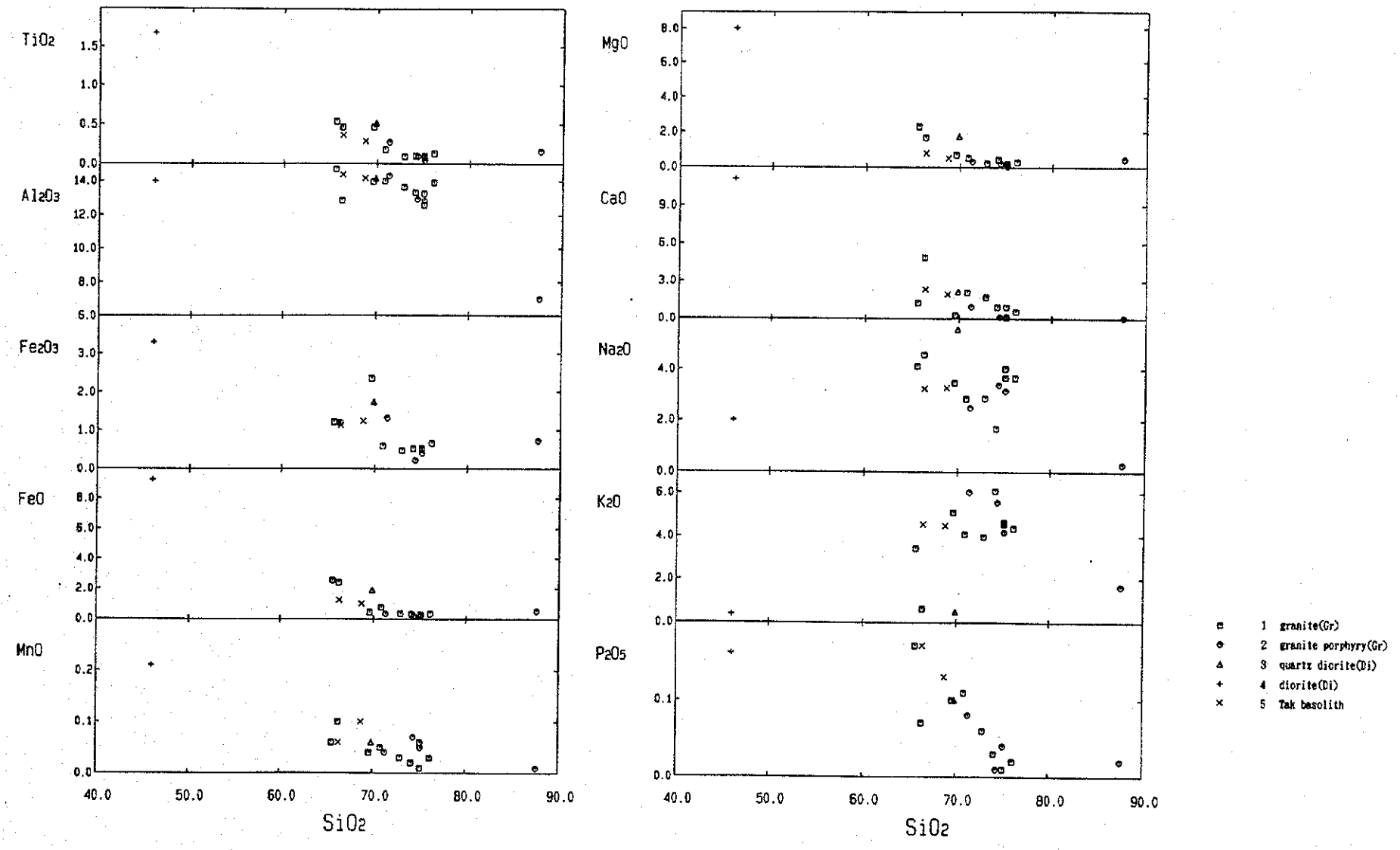
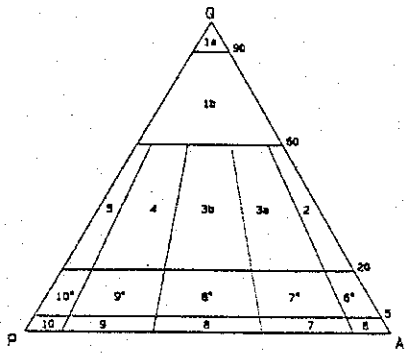


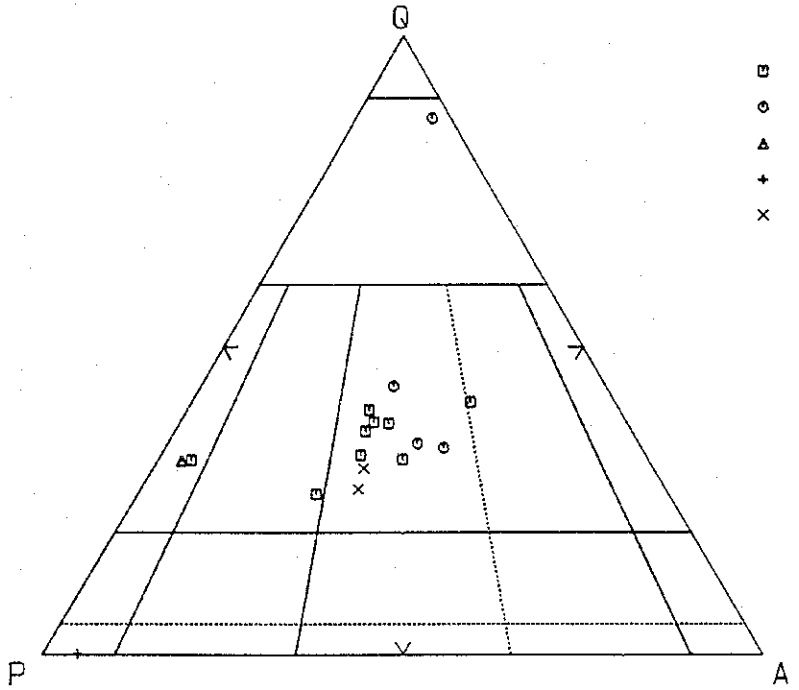
Fig.17 Variation diagrams of igneous rocks in Doi Chong area



Classification of granitic rocks
(IUGS, 1973)

Q — quartz ; A — alkali feldspar [including microcline, orthoclase, sanidine, anorthoclase, and perthites (including their plagioclase components), and plagioclase An-0-5] ; P — plagioclase other than An-0-5 ; F — feldspathoids (leucite and pseudoleucite, nepheline, sodalite, nosean, hauyne, cancrinite, analcime, etc.

1a, quartzolite (silexite) ; 1b, quartz-rich granitoids ; 2, alkali-feldspar granite ; 3, granite ; 4, granodiorite ; 5, tonalite ; 6*, quartz alkali-feldspar syenite ; 7*, quartz syenite ; 8*, quartz monzonite ; 9*, quartz monzodiorite/quartz monzogabbro ; 10*, quartz diorite/quartz gabbro/quartz anorthosite ; 6, alkali-feldspar syenite ; 7, syenite ; 8, monzonite ; 9, monzodiorite/monzogabbro ; 10, diorite/gabbro/anorthosite



1 granite(Gr)
2 granite porphyry(Gr)
3 quartz diorite(Di)
4 diorite(Di)
5 Tak basolith

Fig.18 Normative Q-P-A diagram in Doi Chong area

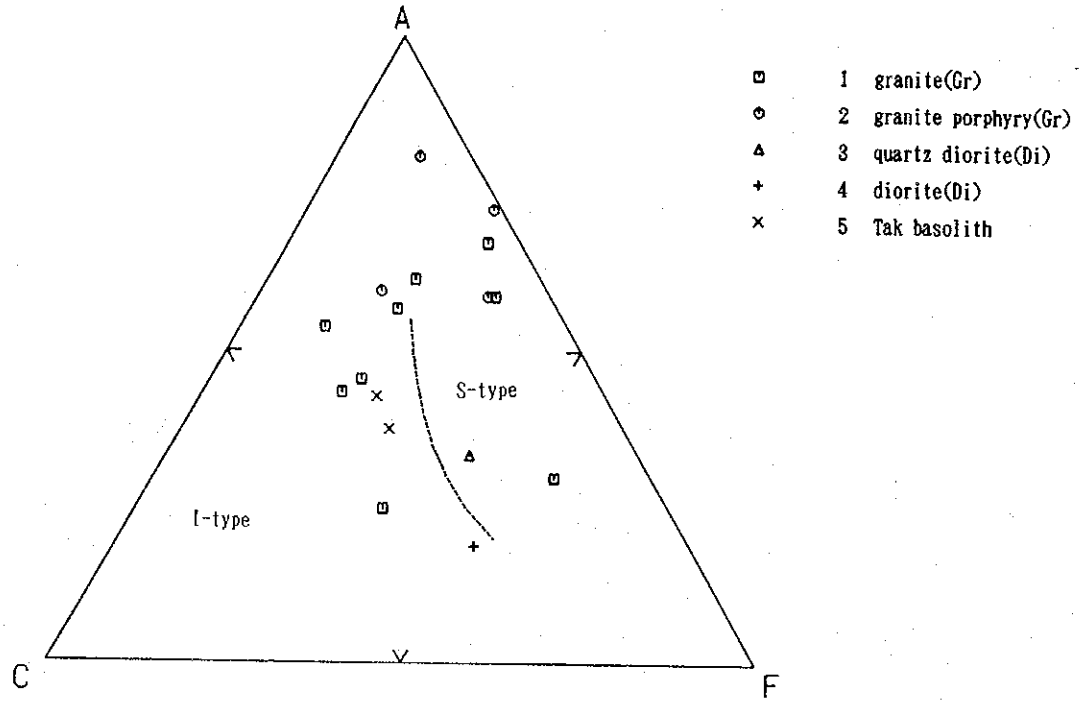


Fig.19 ACF diagram in Doi Chong area

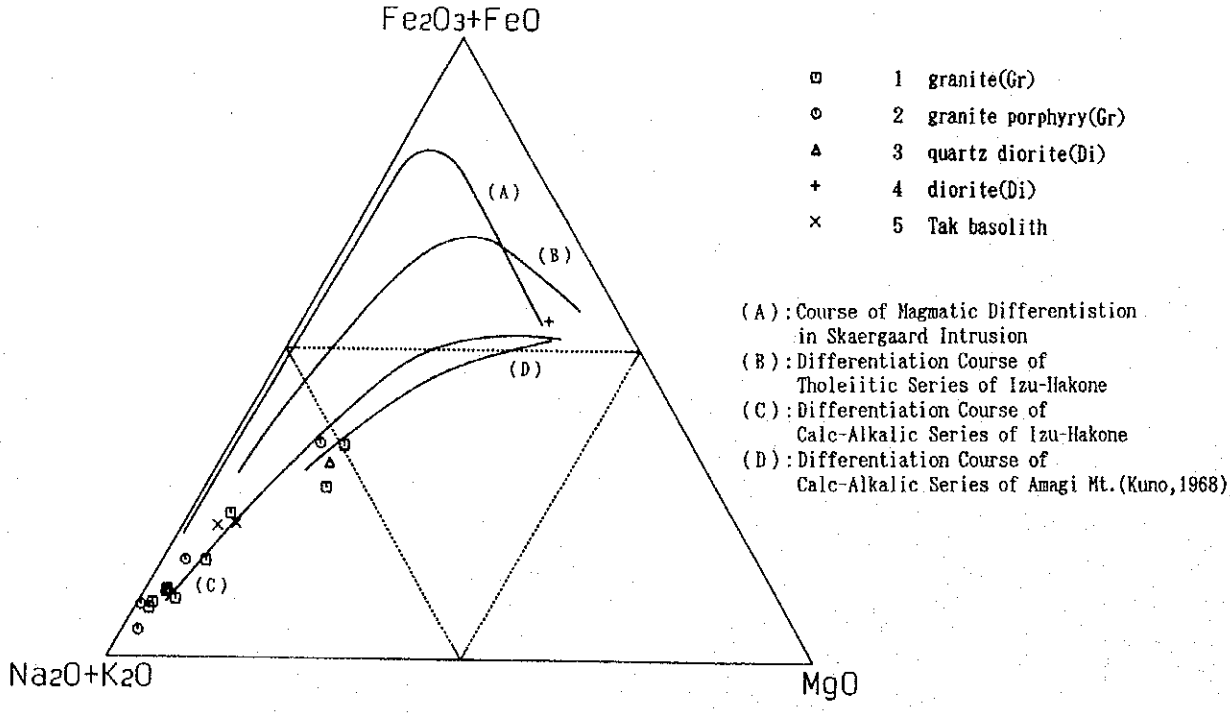


Fig.20 MFA diagram in Doi Chong area

porphyry, the range is narrow with SiO_2=65 to 75%. The behavior of the individual elements is similar, but the 2 samples of Tak batholith come within the category of basic even in the granite of the Doi Chong area, and it is observed that the behavior of TiO_2, MgO, Na_2O, etc. is rather different to that of the granite of the Doi Chong area. Judging from the fact that diorite and quartz diorite form the same rock body, they are thought to have derived from one magma, but considering the behavior of MgO, Na_2O, K_2O and P_2O_5, it is clear that their differentiation trend is different to that of granite. This suggests that the original granite magma and original diorite magma were clearly different.

In the ACF diagram in Fig.19, the granite porphyry is classified for the most part as S-type, but the granite and diorite are plotted as both S-type and I-type. This fact coincides with the finding by Mahawat et al. (1990) that the granite in this vicinity is both S-type and I-type.

In the MFA diagram in Fig.20, the differentiation route of granite in this area conforms well to that of island arc calc-alkali rock series. There are no analytical values for the volcanic rock, but there is thought to have been igneous activity by island arc in this area.

2-5 Mineral Deposits and Occurrences

A map showing the location of mineral occurrences in the Doi Chong area is shown in Fig.21.

There used to be 2 fluorite mines in the Doi Chong area. One is situated about 1km north of Ban Mae Toen and is massive ore lying in Permian phyllite, accompanied by argillized zones between the host rocks. The deposit extended for a length of 150m, a depth of 10 to 20m and a vein width of 5 `20m with ore reserves of 30,000t. Work began on the road way in 1968, but was abandoned following loss of life when the tunnel collapsed around 1987.

The other mine is situated in the hilly region 200m east of Wat Mae Keang in Ban Mae Keang. Prospecting was carried out by a Japanese company in 1975, but later the operating rights passed to a Chinese company and it was developed by open cut mining. There are many points concerning the scale of the deposits, etc. that are not clear, but like the deposits at Mae Toen, there was massive ore inside phyllite that bended in a shape along the fault and the bended parts were massive bonanza. At the present time, mining remains extend over an area 100m wide by 300m long. It is said that ore still remains today in deep parts. Observation of waste ore showed breccia-form silicified veins and chalcedonic silicified rock accompanied by small quantities of sulfide mineral.

Old gold mining are distributed in 2 places, one east of Ban Na Ban Rai and the other on the west side of Wat Tham Suk Kasem Sawan, 2.5km further north. The former is a well-rounded float of quartz veins lying in the flat laterite soil, and there are pits and mounds of excavated ground in the range of 50 x 60m (Fig.21). The highest result obtained in geochemical prospecting of the soil is 477ppb and the gold content is not very high. Gold flakes were confirmed by panning

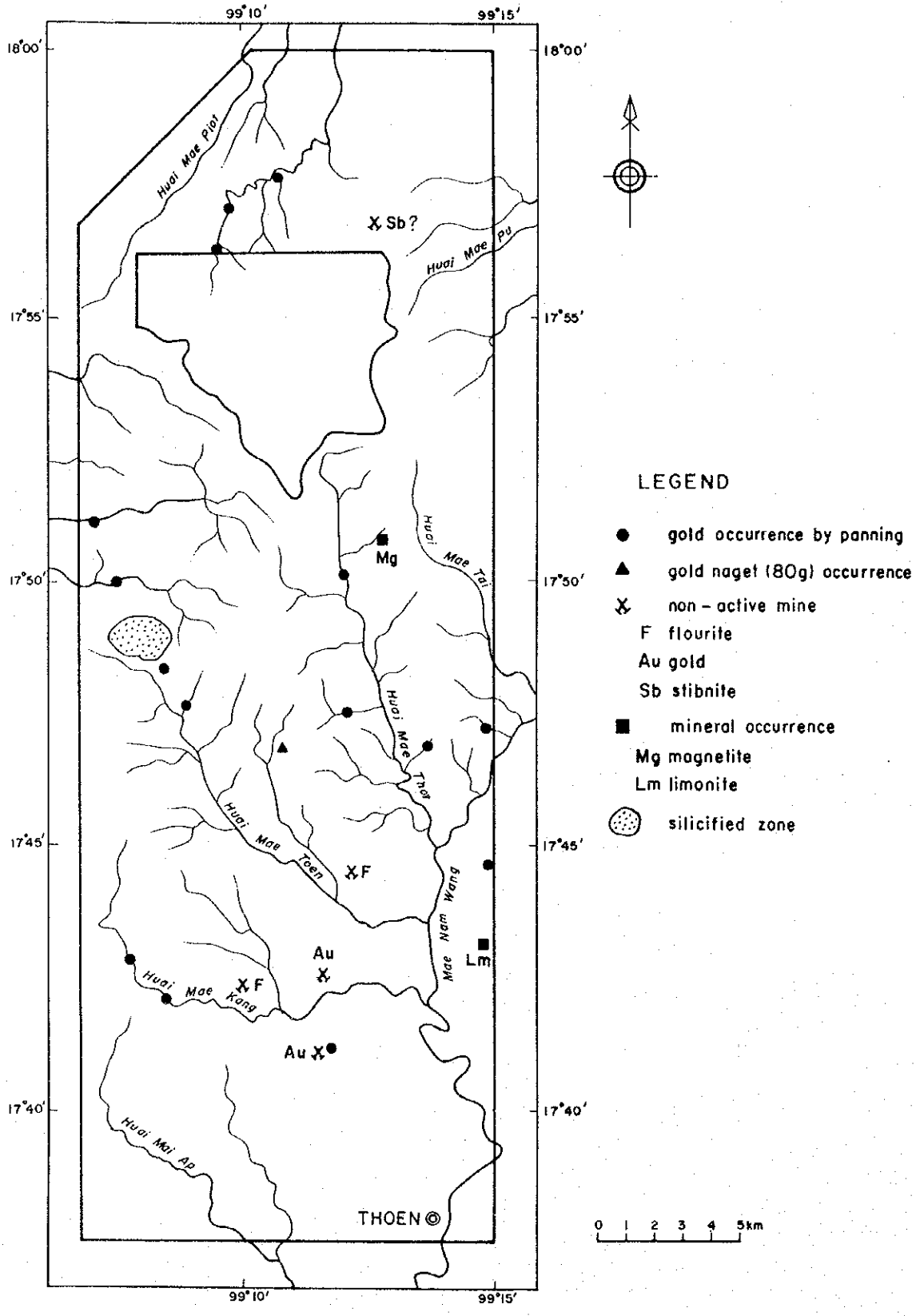


Fig.21 Location map of mineral occurrence in Doi Chong area

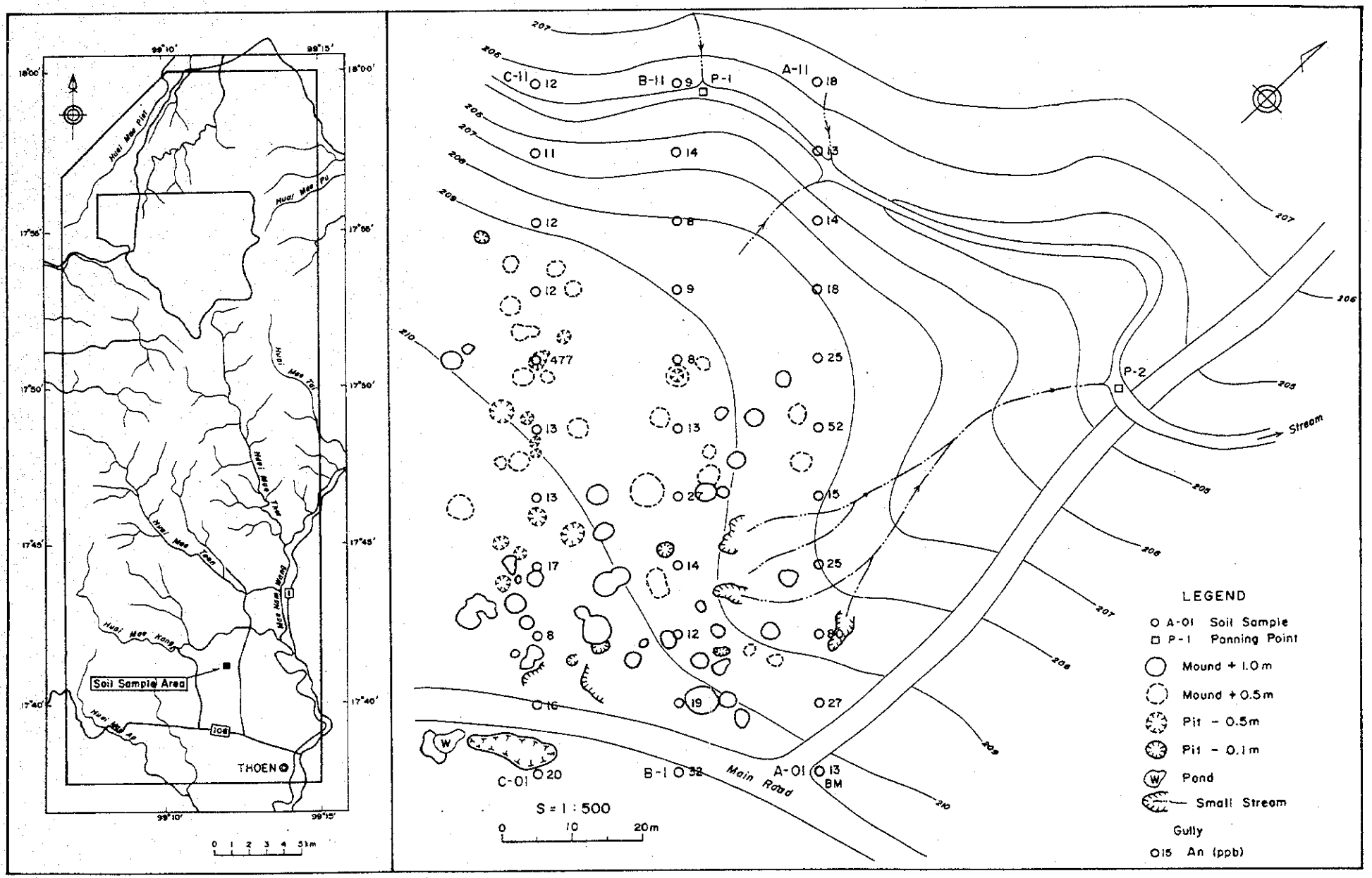


Fig.22 Sketch map of gold occurrence in eastern Ban Na Ban Rai

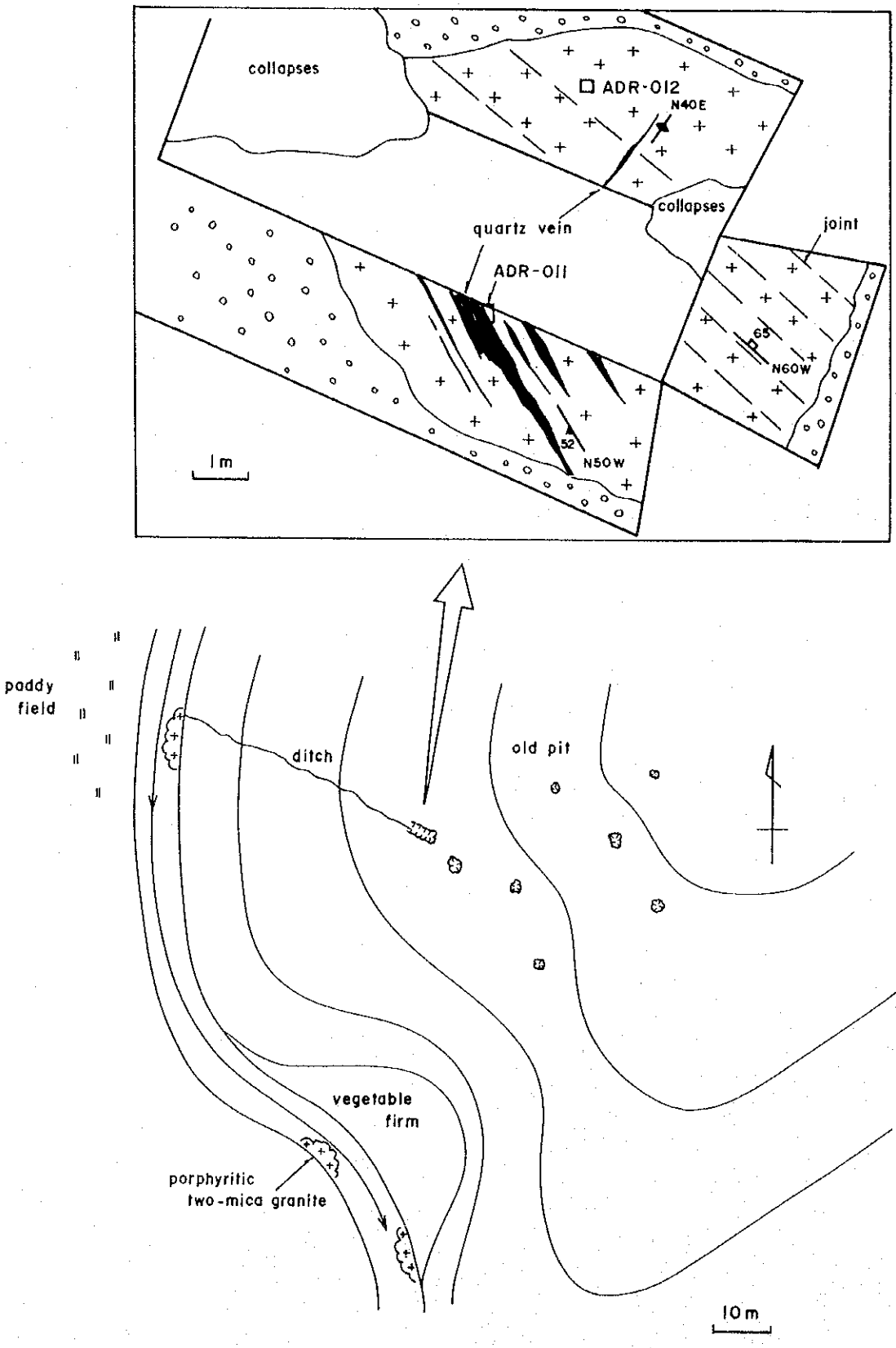


Fig.23 Sketch of gold occurrence in northern Ban Na Ban Rai

at point P-2 in the stream north of the excavation area. The latter is a hilly region with a relative height of 20m or less, formed by mica schist and two-mica granite, and enormous quartz vein rocks are scattered over a wide area on the ground surface. Pits up to 2m deep are scattered along the hillsides (Fig.22). After mining the black and gray quartz vein developing mainly in the granite and crushing it with a stamp mill, only the visible golds were collected by panning. Today, the mine is disused because the high-grade quartz veins have been exhausted. Host rock granite and quartz veins from the pit were analyzed, but they both gave a result of Au0.03g/t.

In addition, there is known to be magnetite occurrence on the side of Doi Chong on the left bank of the upper reaches of Huai Mae Thot, and limonite occurrence in Huai Hia in the southeast of the region. A careful investigation was carried out within the DMR's narrow range, but it did not lead to development.

According to information obtained from local residents, there used to be antimony deposits near the granite in Huai Mae Haet.

No other mineral occurrence were observed during the field survey, but it was confirmed that there are veins of aplite several meters wide scattered in the Doi Chong area, accompanied by small-scale silicification nearby. Moreover, large-scale silicified zones are distributed near the diorite in the upper reaches of Huai Mae Toen. The grade of the quartz veins, altered rocks, etc. in the Doi Chong area are given in Appendix 8.

2-6 Geochemical Prospecting

2-6-1 Sample collecting and pathfinder elements

Sampling was conducted in the Doi Chong area in the same way as in the Chiang Khong area and 623 samples were taken. The locations where the samples were taken are given in PL-10 together with the locations of the samples taken by panning and the locations of the rock samples.

S-type granite is known to exist in the Doi Chong area, and from the fact that occurrence of tin, niobium and tantalum was anticipated, 15 elements were taken as pathfinder elements: Au, Ag, Cu, Pb, Zn, Hg, As, Fe, S, W, Sn, Sb, F, Ta, and Nb.

2-6-2 Analysis of data

1. Processing of statistics

The statistics were processed using the same logarithm values as for the Chiang Khong area. The maximum value, minimum value, mean value and standard deviation for each element are shown in Table 8. The frequency distribution and cumulative frequency curve map are shown in Fig.24.

The correlation coefficients for each element are shown in Table 9.

Au shows a weak positive correlation to As. There is a strong positive correlation to Zn, Cu and Fe, and a weak positive correlation to these elements and to F, As and Sb is seen.

A positive correlation to Pb, F, Sb and Ta is seen. Furthermore, there is a strong positive correlation to Nb and Ta. No correlation is seen by Ag, Hg, Sn and S to any other elements.

Table 8 Basic statistic quantities of stream sediments in Doi Chong area

element	unit	det. limit	Maximum	Minimum	Average	Log. Std. Dev
Au	ppb	1	2180	< 1	1.44	0.6618
Ag	ppm	0.2	0.2	<0.2	0.10	0.0339
Cu	ppm	1	88	< 1	11.40	0.3329
Pb	ppm	2	184	< 2	18.75	0.3753
Zn	ppm	2	110	2	31.51	0.2827
Hg	ppb	10	4450	< 10	14.50	0.3945
As	ppm	2	192	< 2	13.83	0.5448
Fe	%	0.01	15.0	0.20	2.06	0.2469
S	%	0.01	0.07	<0.01	0.007	0.2073
W	ppm	10	60	< 10	5.04	0.0550
Sn	ppm	2	9	< 2	1.06	0.1274
Sb	ppm	2	36	< 2	1.75	0.2933
F	ppm	20	>10000	60	192.90	0.1972
Ta	ppm	1	37	< 1	1.50	0.3386
Nb	ppm	5	232	6	21.49	0.2030

Table 9 Geochemical correlation coefficients of stream sediments in Doi Chong area

	Au	Ag	Cu	Pb	Zn	Hg	As	Fe	S	W	Sn	Sb	F	Ta	Nb
Au	1.0000														
Ag	-0.0009	1.0000													
Cu	0.1400	0.0154	1.0000												
Pb	0.1246	0.0409	0.0794	1.0000											
Zn	0.1884	0.0166	**0.8327**	0.3989	1.0000										
Hg	0.1424	-0.0140	0.0964	0.0296	0.1097	1.0000									
As	0.3380	-0.0219	0.3354	**0.4410**	0.4939	0.1644	1.0000								
Fe	0.1436	-0.0330	**0.8910**	0.1218	**0.7984**	0.1612	0.3294	1.0000							
S	0.0927	0.0851	0.2288	0.0602	0.2607	0.1803	0.1580	0.1865	1.0000						
W	0.0129	-0.0076	0.0303	0.0805	0.0587	-0.0407	0.0462	0.0182	0.0171	1.0000					
Sn	0.0851	-0.0231	0.0846	0.1120	0.0725	-0.0286	0.0531	0.0539	-0.0578	-0.0135	1.0000				
Sb	0.1985	-0.0658	0.2706	0.1238	0.2615	0.2300	0.3127	0.3229	0.0682	0.0633	0.0072	1.0000			
F	0.2033	0.0372	0.4072	0.4840	**0.5997**	0.0299	0.4595	0.3929	0.2040	0.1736	0.0680	0.1483	1.0000		
Ta	0.0710	-0.0230	-0.1640	0.4644	0.0889	-0.1153	0.2143	-0.1646	-0.0718	0.0576	0.1191	-0.0567	0.3755	1.0000	
Nb	0.0354	-0.0027	-0.2704	0.2930	-0.0611	-0.0857	0.1143	-0.2886	-0.0588	0.0241	0.0883	-0.1354	0.2508	**0.7899**	1.0000

2. Deciding the thresholds

As in the Chiang Khong area, the mean values and standard deviation were taken as the main standards, with the frequency distribution and cumulative frequency curve map added to determine the thresholds. The thresholds for each element are shown in Table 10.

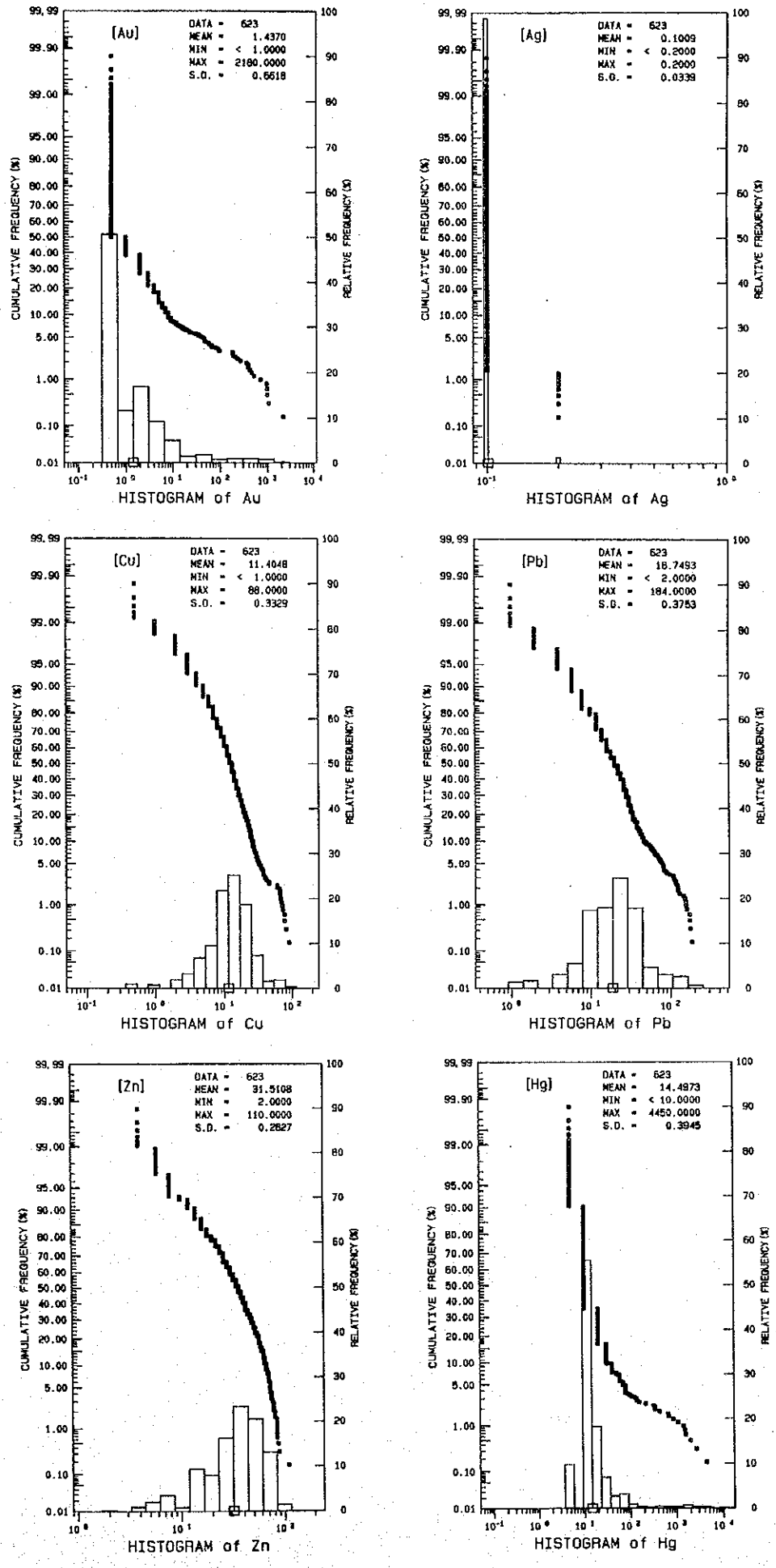


Fig.24 Relative frequency and cumulative frequency histogram of stream sediments in Doi Chong area (1)

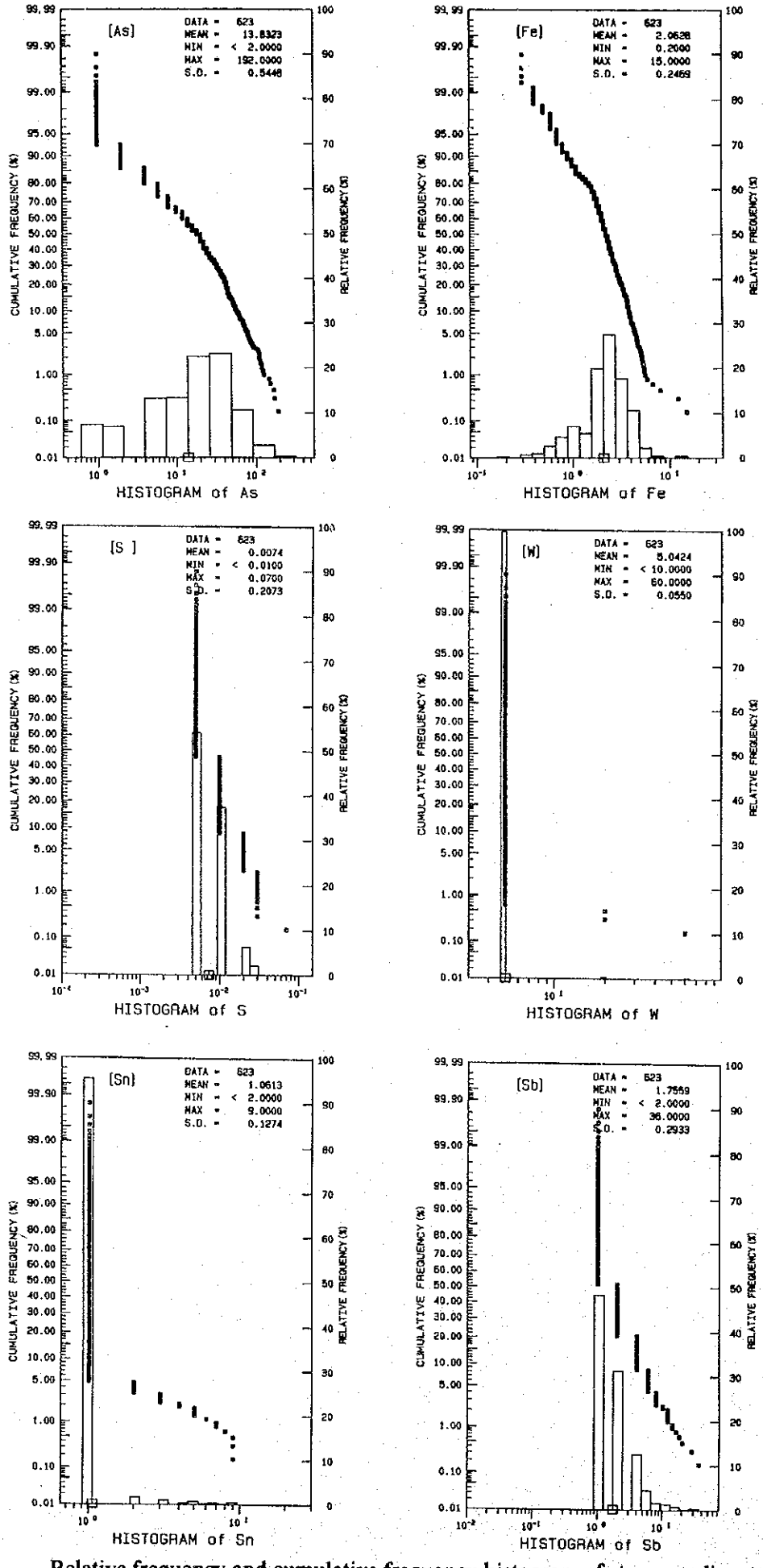


Fig.24 Relative frequency and cumulative frequency histogram of stream sediments in Doi Chong area (2)

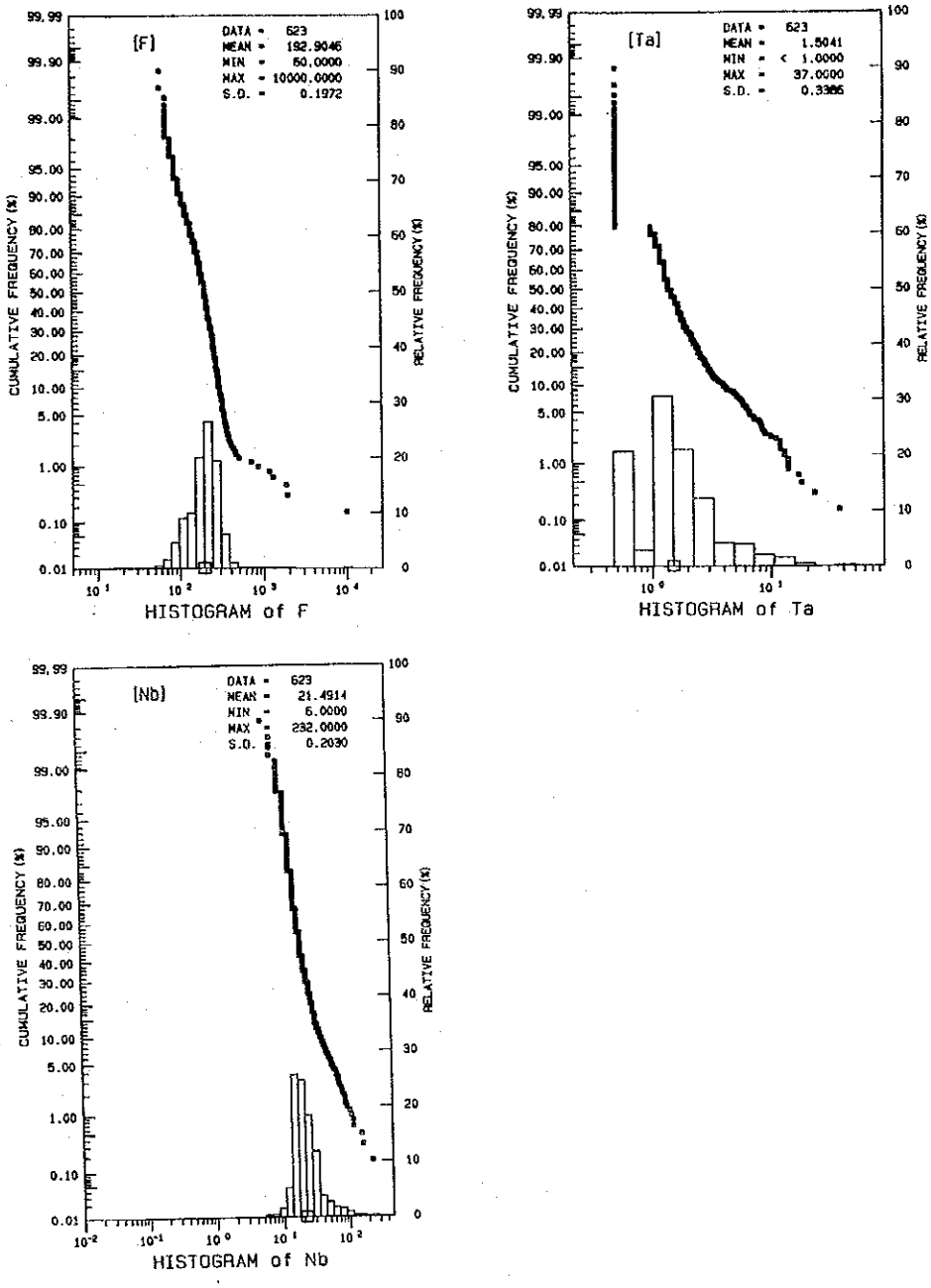


Fig.24 Relative frequency and cumulative frequency histogram of stream sediments in Doi Chong area (3)

3. Distribution of anomaly zones

An anomaly zone distribution map for each element was drawn up on the basis of the divisions in Table 10 (Fig.25). Distribution of the anomaly zones for each element is explained below.

Table 10 Division into geochemical anomaly levels of stream sediments in Doi Chong area

element	unit	low anomaly	background	high anomaly1	high anomaly2	high anomaly3
Au	ppb		M+σ 6.60	M+2 σ 30.27	M+3 σ 139.0	
Ag	ppm		M+0.5 σ 0.105			
Cu	ppm	M-2 σ 2.46	M+σ 29.36	M+2 σ 52.83		
Pb	ppm	M-2 σ 3.33	M+σ 44.49	M+2 σ 105.6		
Zn	ppm	M-1.5 σ 11.86	M+σ 60.42	M+1.5 σ 83.67		
Hg	ppb		M 39.96	M+2 σ 89.19		
As	ppm	M-σ 3.95	M+σ 48.50	M+2 σ 90.80		
Fe	%	M-0.5 σ 1.55	M+σ 3.64	M+1.5 σ 4.84		
S	%		M+1 σ 0.012			
W	ppm		M+0.5 σ 5.37			
Sn	ppm		M 1.06			
Sb	ppm		M+1.5 σ 4.84			
F	ppm		M+σ 303.7			
Ta	ppm		M+σ 3.28	M+2 σ 7.15		
Nb	ppm		M+σ 34.30	M+2 σ 54.74		

[Au]

Anomaly zones are seen in Huai Mae Pu and Huai Wua Sam Tue in the northeast, and Huai Mae Haet and Huai Mae Tam in the center of the northern region. Gold flakes were confirmed by panning in the vicinity of the anomaly zone in the center of the northern region. The occurrence of gold is expected in the hilly region between Huai Mae Pu and Huai Mae Haet. Anomaly zones are distributed in the uppermost reaches of Huai Mae Thot and in Huai Krathing and Huai Pun Yang

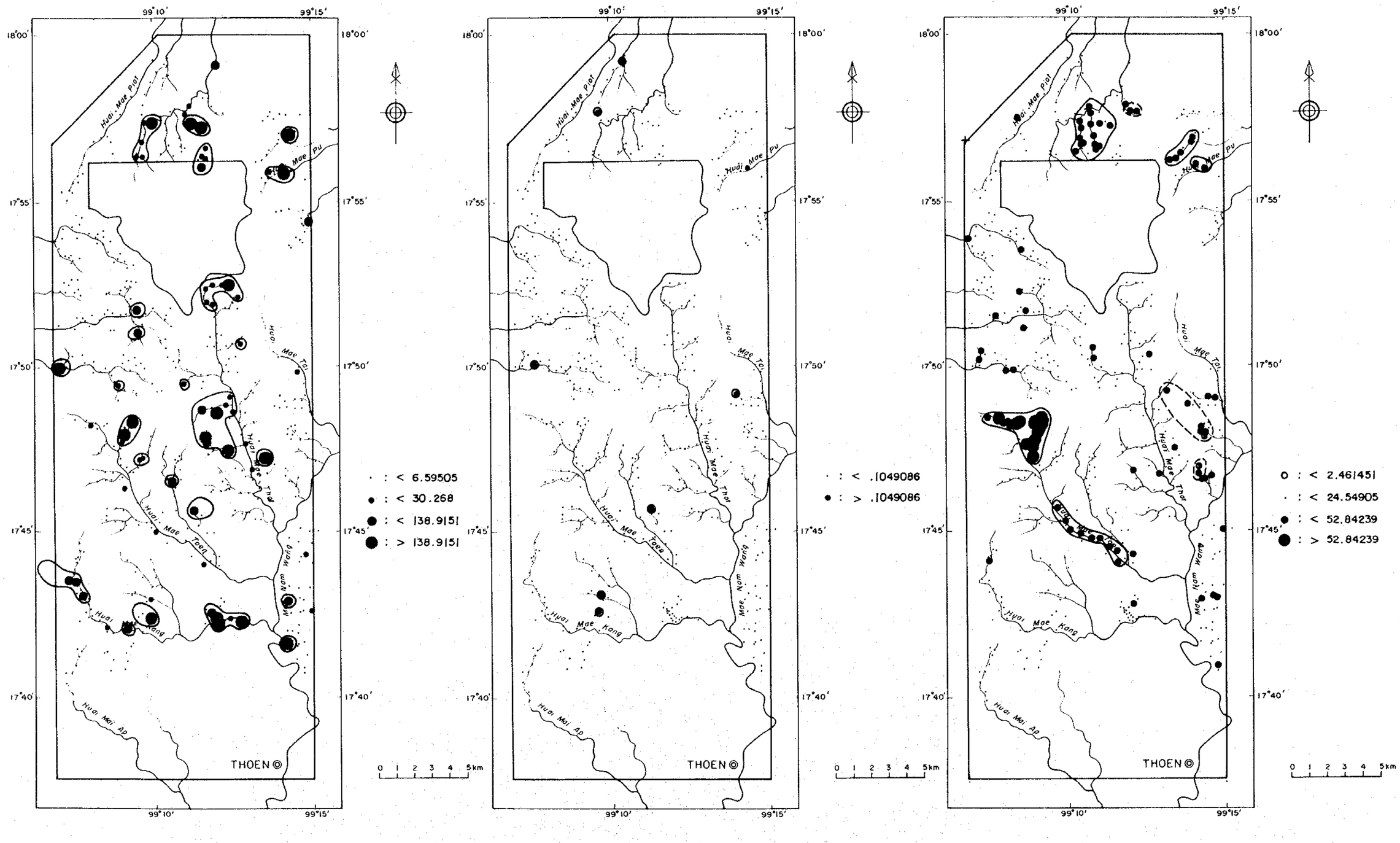


Fig.25 Geochemical anomaly map of stream sediments in Doi Chong area (1)

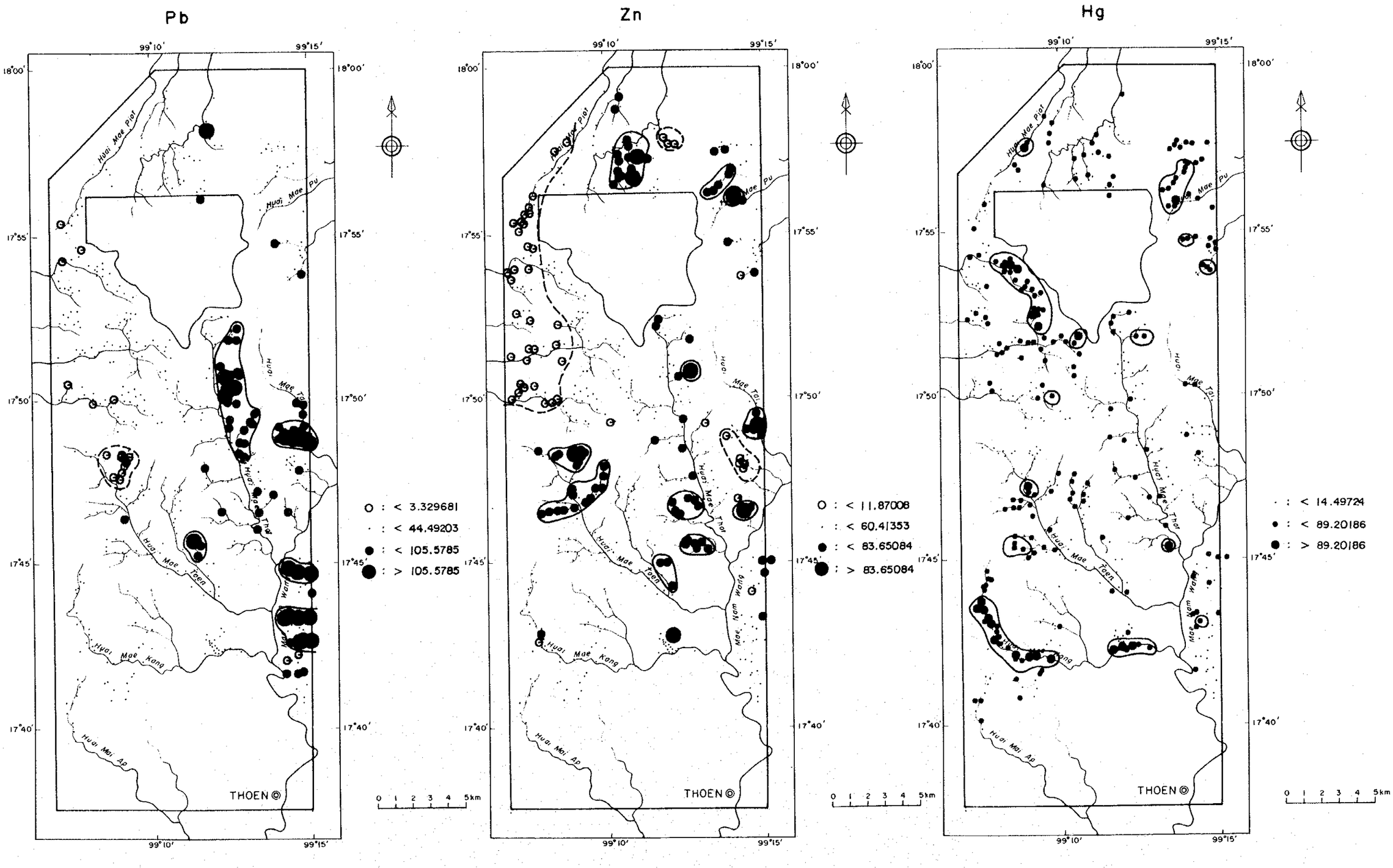


Fig.25 Geochemical anomaly map of stream sediments in Doi Chong area (2)

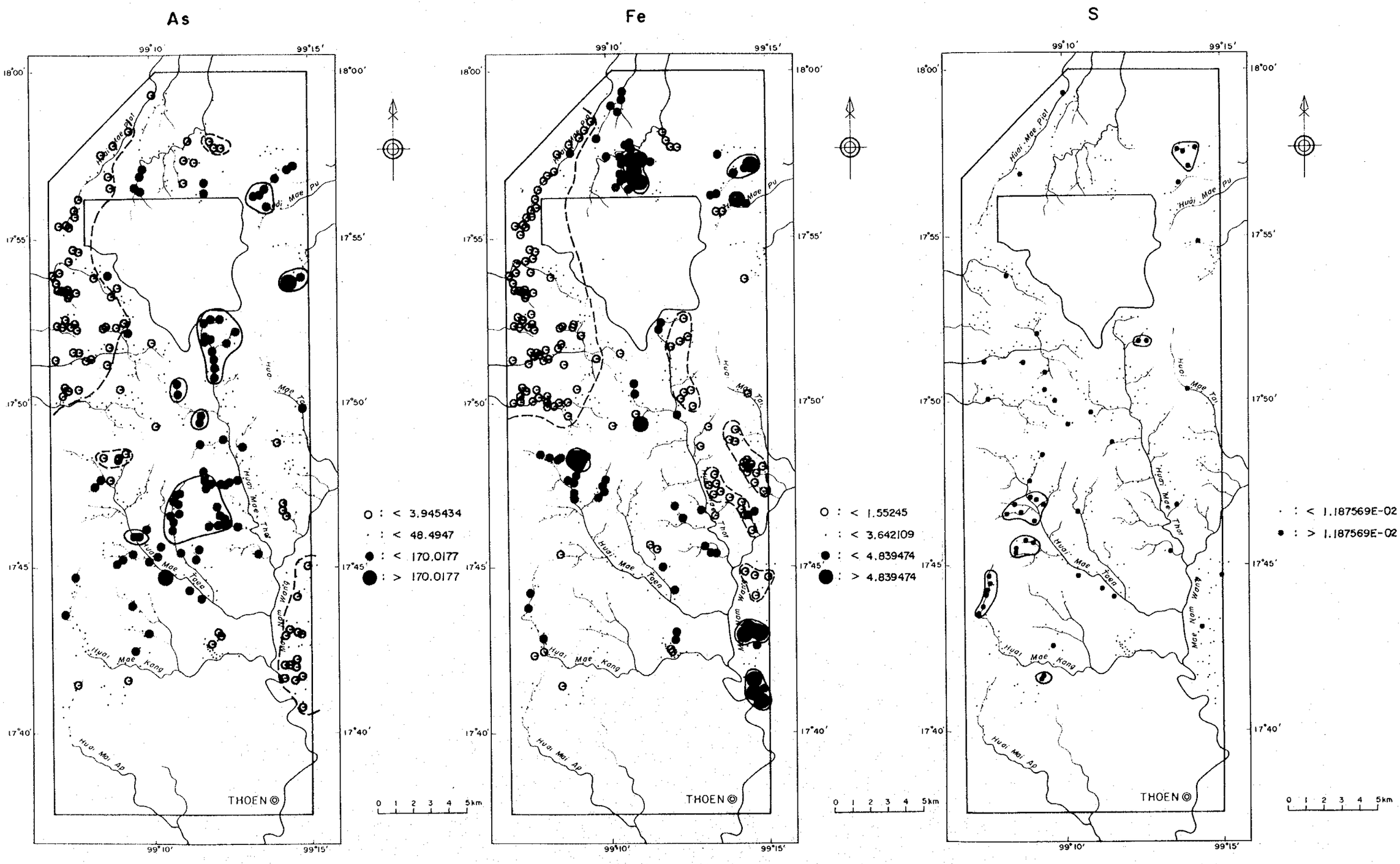


Fig.25 Geochemical anomaly map of stream sediments in Doi Chong area (3)

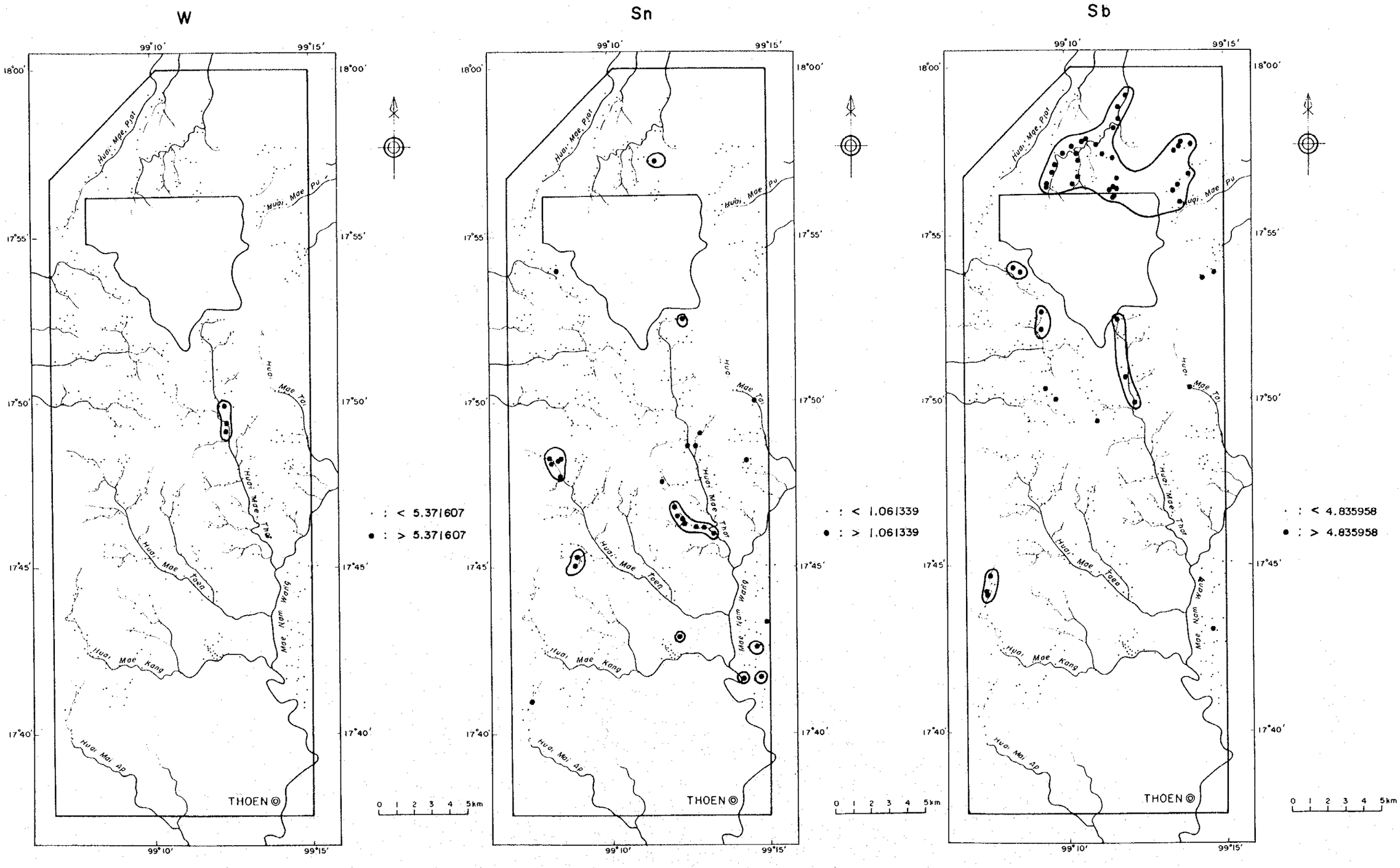
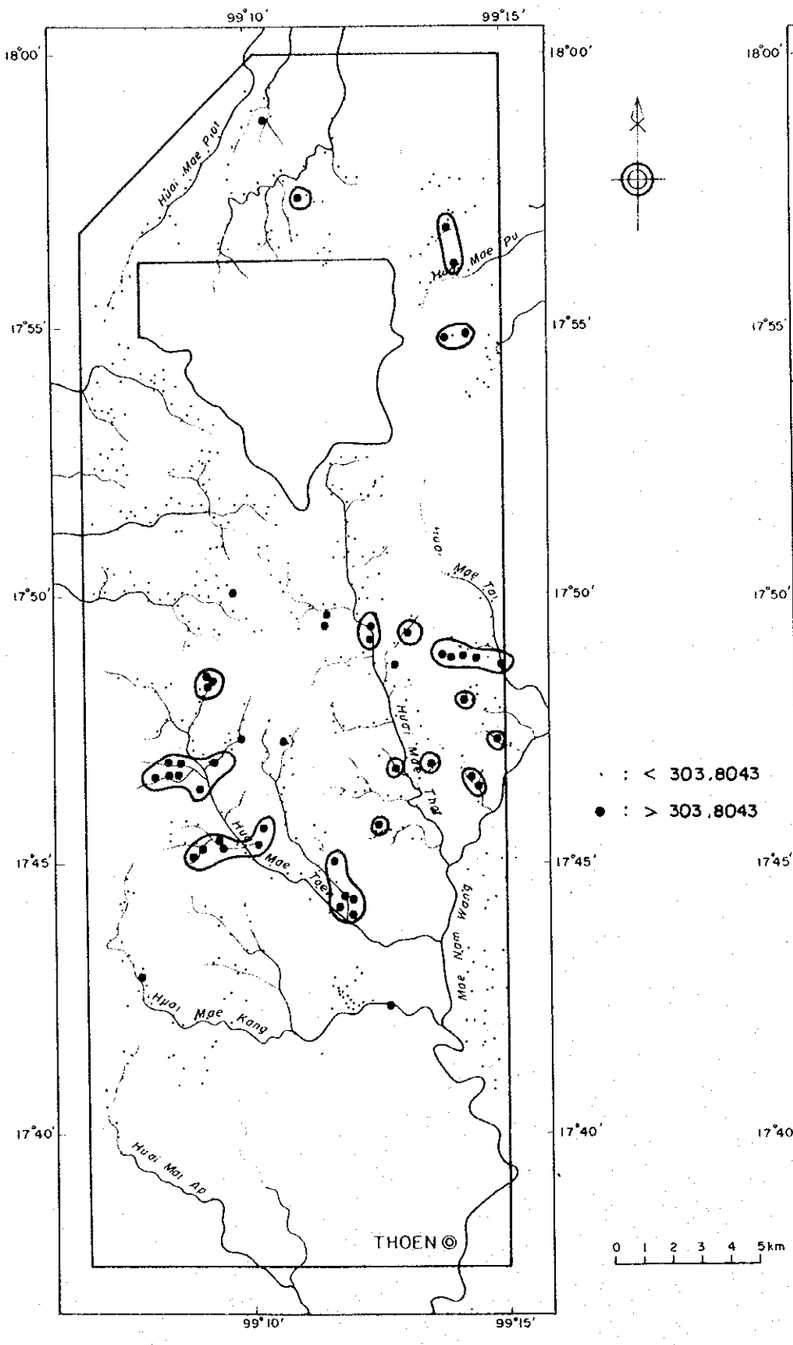
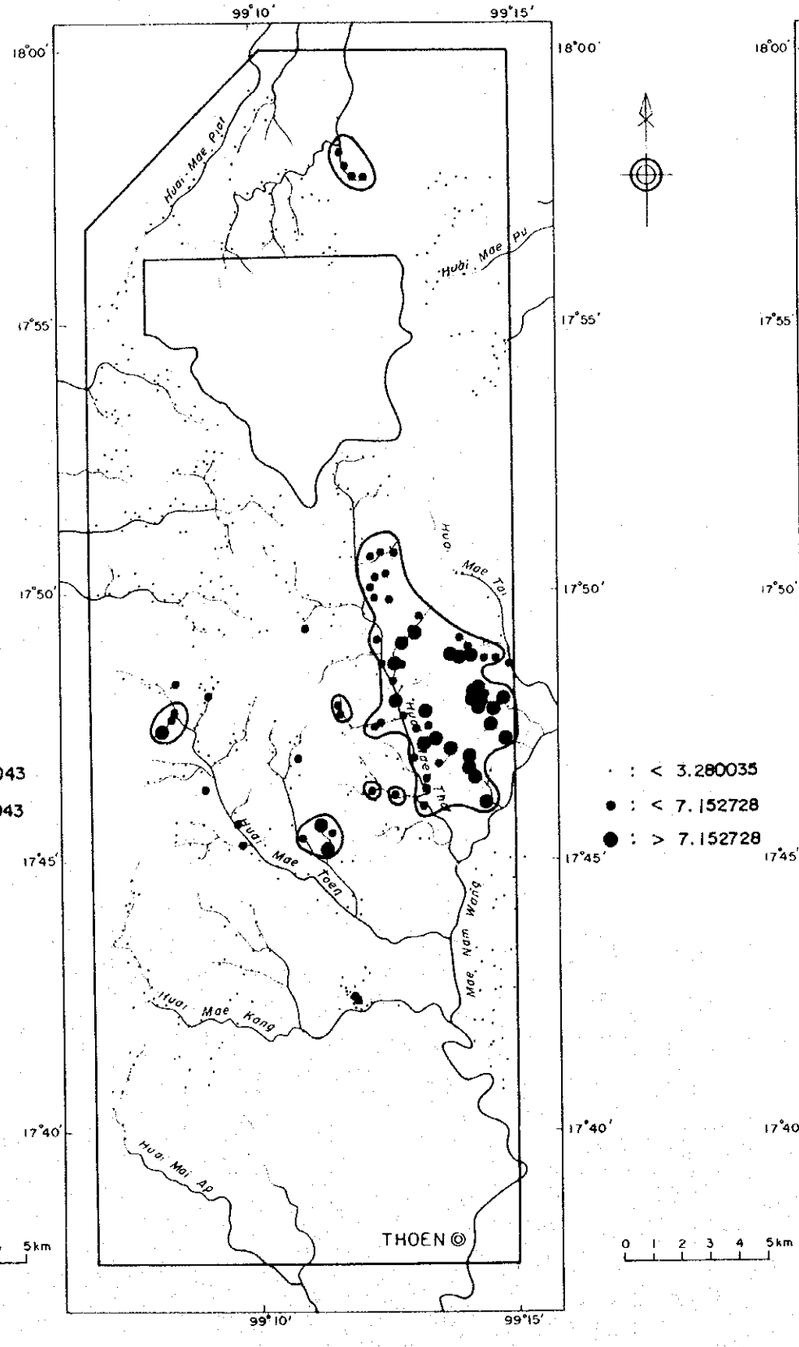


Fig.25 Geochemical anomaly map of stream sediments in Doi Chong area (4)

F



Ta



Nb

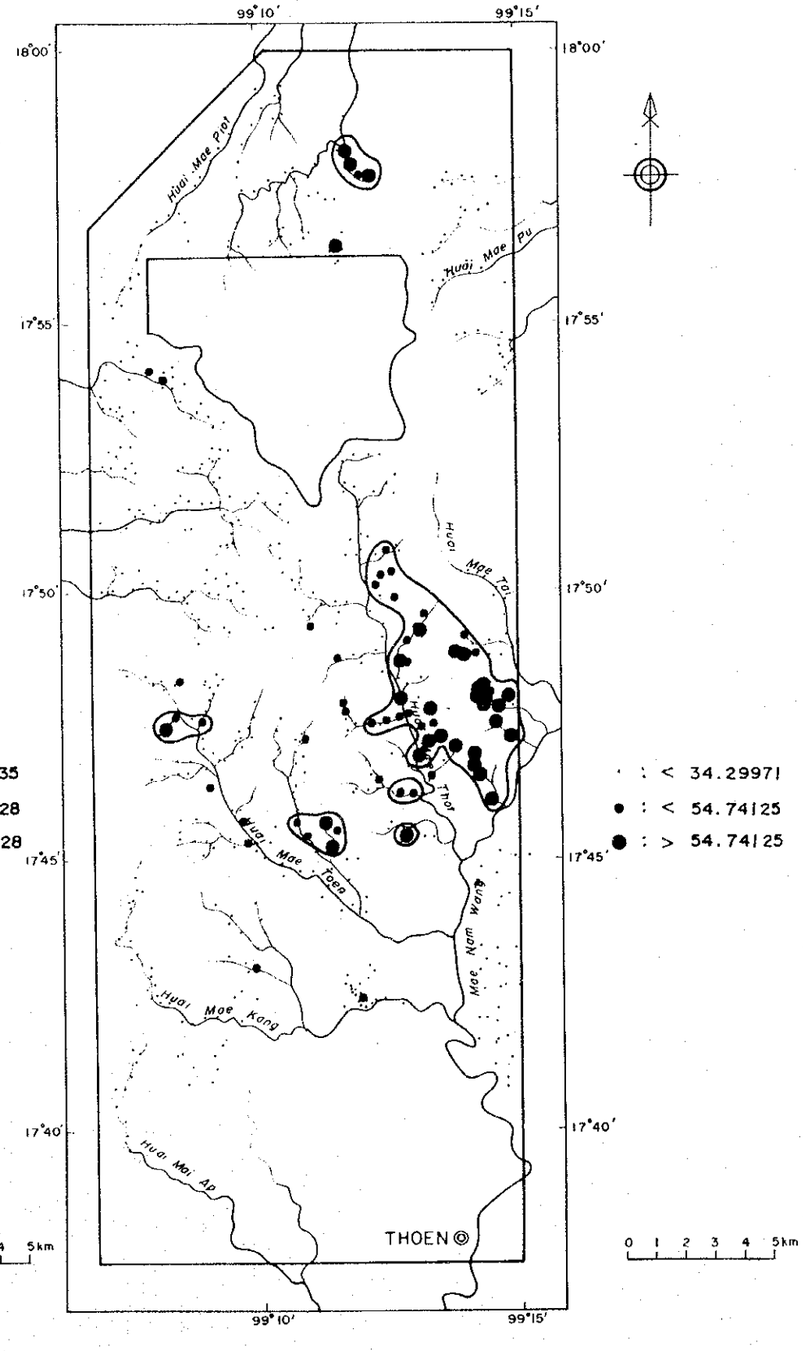


Fig.25 Geochemical anomaly map of stream sediments in Doi Chong area (5)

on the right bank in the middle reaches. Small-scale veins of granite and aplite frequently intrude into the anomaly zones in the tributaries along the extension of the larger granite body, suggesting the occurrence of gold connected with granite.

Anomaly zones are seen in the sandstone stratum in the uppermost reaches of Huai Pong in the west, but no other high zones are shown. High anomaly zones are seen in the lower reaches of Huai Ping where gold was confirmed by panning, but only one result of 18ppb was obtained in the upper reaches.

There are two anomaly zones in the reaches below the diorite in Huai Mae Toen and the highest result of 2,180ppb was obtained in this region. Anomaly zones in the middle reaches of Huai Mae Toen are distributed in the vicinity of small granite bodies. The anomaly zone in the middle reaches of Huai Mae Thot is situated on the other side of the ridge. It corresponds to the place where local residents discovered an 80g nugget.

As for the anomaly zones north of Ban Na Ban Rai, there are anomaly zones in the vicinity of where the local people mined for gold, but the extent of gold occurrence is extremely small and is thought to originate in small granite bodies.

The anomaly zones in Huai Mae Kaeng in the southwest of the area are distributed in the metamorphic rock distribution zones, and no mineralized zones such as might be connected with the anomaly zones are particularly seen.

[Ag]

99% of the values are detection limit values or below. The remaining 8 samples also give detection limit values and none could be said to be anomaly zones.

[Cu]

Anomaly zones of 40 to 90ppm are found in the vicinity of diorite in the upper reaches of Huai Mae Toen and there are thought to be mineral prospects connected with diorite. Chalcopyrite can be seen in the diorite with a microscope. Slight anomaly zones, thought to be halos from these anomaly zones, are distributed in the lower reaches of Huai Mae Toen.

Anomaly zones of around 30ppm are distributed between Huai Mae Haet and Huai Mae Tam in the north of the area and in Huai Wua Sam Tua. The latter overlap with gold anomaly zones and mineralization can be expected.

There is no clear formation of low anomaly zones, but anomaly values are concentrated in the vicinity of the granite distributed on the right bank of Huai Mae Thot and in the northeast of the region.

[Pb]

In addition to the concentration of anomaly zones in the vicinity of the granite body on the right bank of Huai Mae Thot and the granite body in the middle reaches of Huai Mae Toen, anomaly zones are seen to the east of Mae Nam Wang in the southeast of the area. As the former

are closely connected with distribution of Nb and Ta, they may show the existence of uranium. The latter anomaly zones are thought to have derived from mineralization together with Permo-Triassic Lampang-Phrae volcanic rock.

Low anomaly zones are found in the vicinity of diorite in the upper reaches of Huai Mae Toen and overlap with high Cu anomaly zones.

[Zn]

Overall the distribution of the anomaly zones is similar to that of Cu. Unlike copper however, small-scale weak anomaly zones are seen in the granite extension in Huai Mae Thot. Also, weak anomaly zones surround the south side of the diorite body in the upper reaches of Huai Mae Toen.

The low anomaly zones conform to distribution of Permian Kiu Lom Formation and mudstone of Pha Fuat Formation distributed in the northwest.

[Hg]

The anomaly zones overlap with the gold anomaly zones in Huai Mae Pu, Huai Wua Sam Tua and north of Ban Na Ban Rai in the northeast and show occurrence of hydrothermal vein-type minerals.

A high anomaly zone below the Au anomaly zone in Huai Mae Kaeng extends along the stream. No alteration zone that could account for the anomaly zone similar to Au was seen.

A high anomaly zone extends along the fault running NW-SE in the upper reaches of Huai Mae Bon in the northwest of the area, suggesting hydrothermal activity along the fault.

[As]

The anomaly zone overlaps the anomaly zone for Au in the upper reaches of Huai Mae Pu, and anomaly zones are distributed south of the Au anomaly zones in the upper reaches of Huai Mae Thot and between Huai Mae Thot and Huai Mae Toen. This shows that there are more As anomaly zones distributed by the granite than Au anomaly zones.

In addition to the low anomaly zones which extend to the northwest of the area similarly to Zn, low anomaly zones are also seen in the southwest of the region.

[Fe]

Distribution of high anomaly zones for iron is extremely small and the zones overlap Cu anomaly zones in the lower reaches of Huai Wua Sam Tua, between Huai Mae Thot and Huai Mae Tam in the north of the area, and in the diorite region in the upper reaches of Huai Mae Toen.

Anomaly zones are also seen on the east bank of Mae Nam Wang, but this is thought to show the occurrence of limonite.

In addition to the low anomaly zones overlapping Zn and As anomaly zones in the northwest of the area, low anomaly zones are also distributed in the vicinity of granite on the left bank of Huai Mae Thot.

[S]

Over 90% of the values are the detection limit value of 0.01% or below, with values exceeding 0.03% obtained from only one sample. Anomaly zones are seen in Huai Wua Sam Tua, on the left bank of the upper reaches of the Huai Mae Toen and in the upper reaches of Huai Mae Kaeng.

[W]

Only three samples gave values over the detection limit value. All the zones are distributed in the middle reaches of Huai Mae Thot.

[Sn]

Around 95% of the values are below the detection limit value. Anomaly zones are distributed accompanied by silicified rock on the left bank in the middle reaches of Huai Mae Thot, in the vicinity of small granite bodies on the right bank of Huai Mae Thot and in the vicinity of diorite in Huai Mae Toen.

[Sb]

Over 75% of the values are below the detection limit value.

The anomaly zones are distributed along the fault from the center to the south and form a wide-ranging anomaly zone in the north from Huai Mae Pu to Huai Mae Tam.

[F]

The pattern of anomaly zones is similar to that of Zn. Distribution in the southern area is mostly in the vicinity of granite or diorite. No distribution of granite is seen on the right bank in the middle reaches of Huai Mae Toen, but anomaly zones are distributed over a wide range, suggesting the existence of subsurface plutonic rocks.

[Ta, Nb]

As the correlation coefficients show, these elements show extremely similar anomaly zone distribution. The anomaly zones overlap with the distribution of granite. High anomaly zones are concentrated in particular in the vicinity of granite on the right bank of Huai Mae Thot.

No distribution of granite is seen on the right bank in the middle reaches of Huai Mae Toen, but anomaly zones are distributed together with those of Zn, F, etc., showing the possible existence of subsurface plutonic rocks.

4. Analysis of Principal Components

Principal components analysis of 11 of the components, excluding Ag, S, W and Sn for which over 90% of the samples show detection limit values or below, was carried out of the correlation matrices obtained from logarithm values of geochemical analytical values. The results are shown in Table 11.

The eigenvalues are 1 or over, or are close to 1, up to the fourth component, and the cumulative contribution rate up to the fourth component is 75%. Score distribution up to the fourth component is shown in Fig.26.

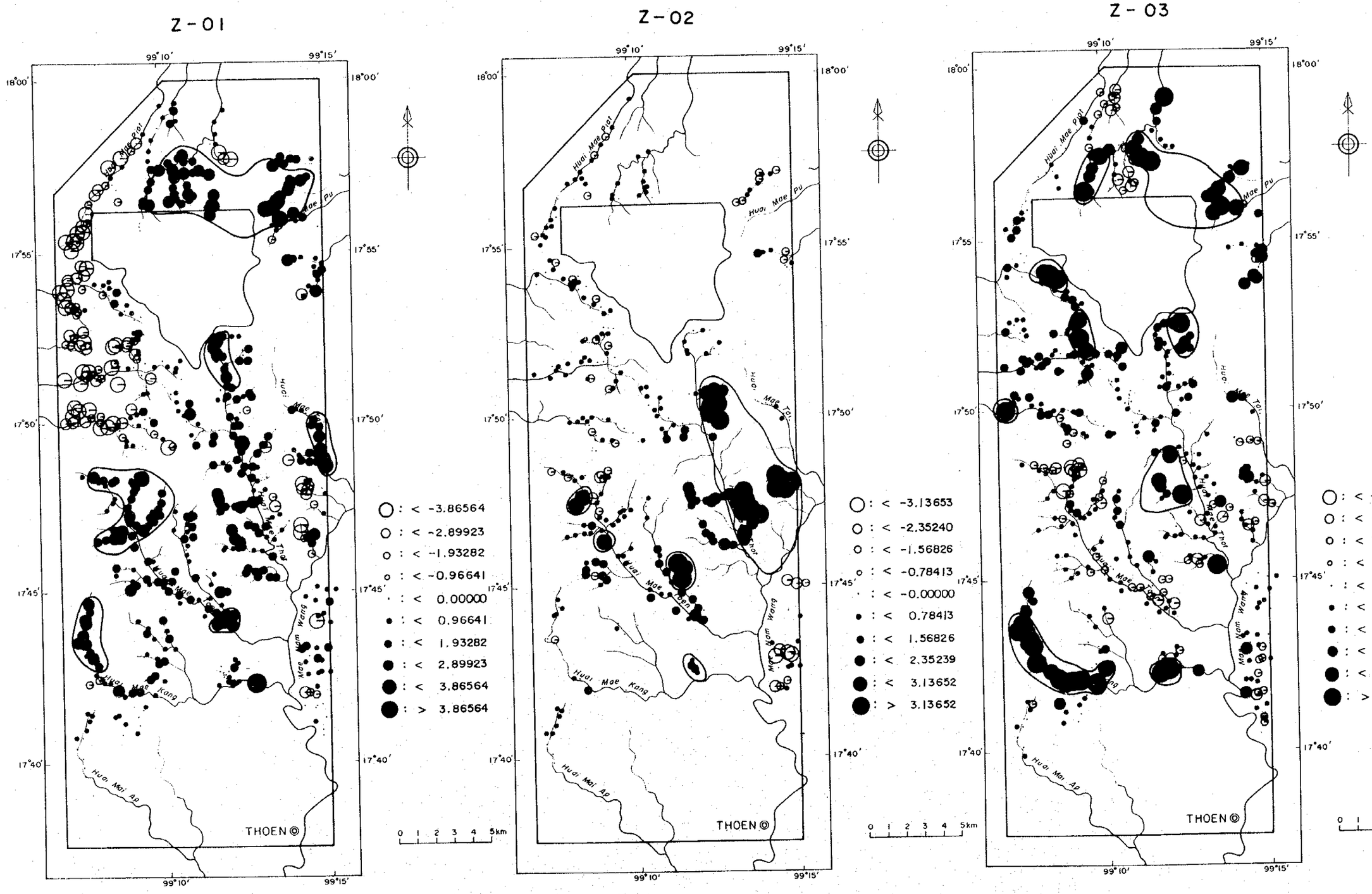


Fig.26 Scores of principal components analysis in Doi Chong area (1)

Z - 04

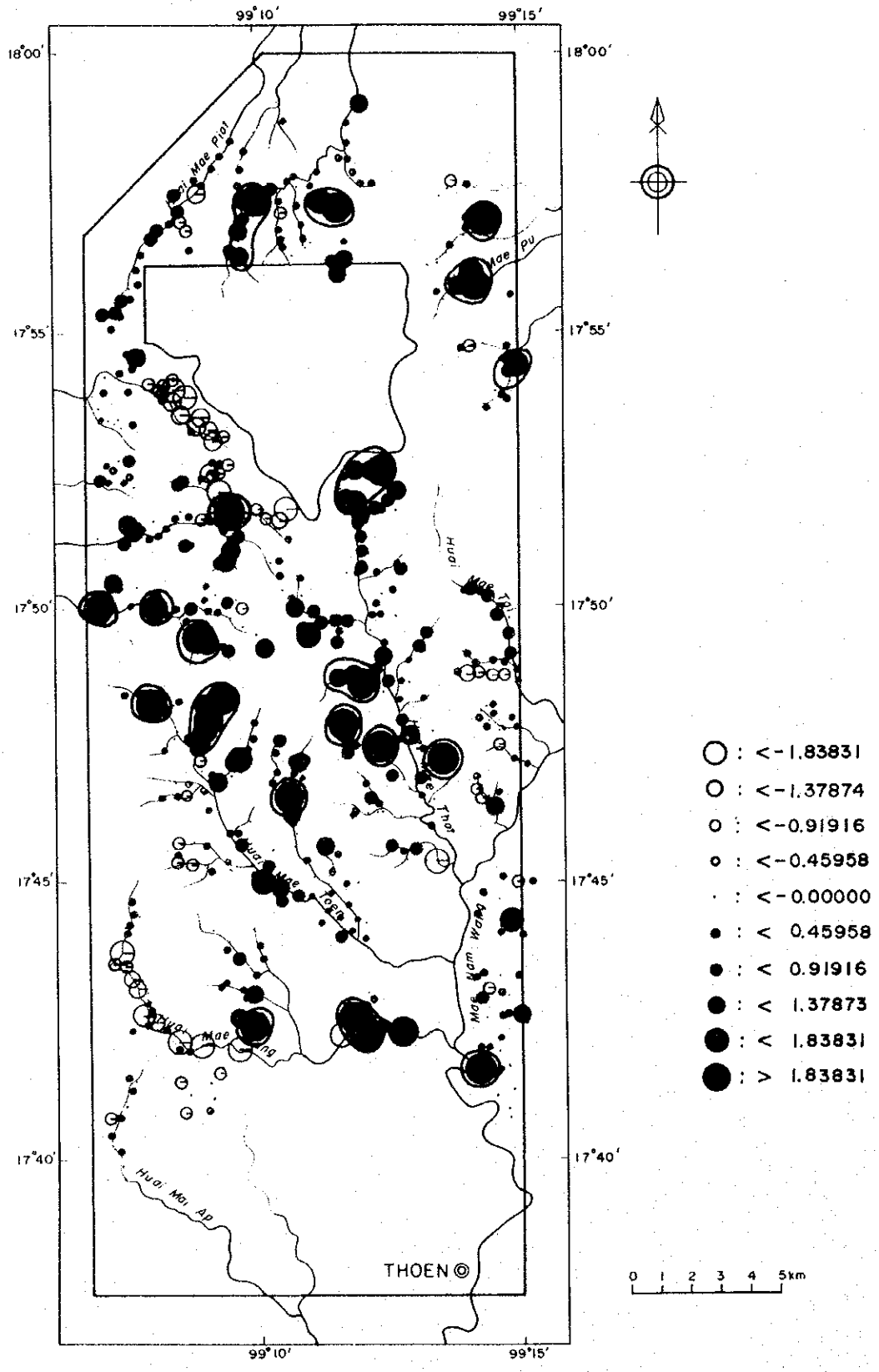


Fig.26 Scores of principal components analysis in Doi Chong area (2)

Table 11 Results of principal components analysis in Doi Chong area

Principal componet	Eigen-value	Contribu-tion rate%	Cumulaive%
Z-01	3.7358	33.9617	33.9617
Z-02	2.4594	22.3586	56.3203
Z-03	1.2445	11.3137	67.6340
Z-04	0.8448	7.6804	75.3145
Z-05	0.7492	6.8113	82.1258
Z-06	0.6715	6.1043	88.2301
Z-07	0.4726	4.2965	92.5265
Z-08	0.4168	3.7895	96.3160
Z-09	0.1828	1.6615	97.9775
Z-10	0.1350	1.2271	99.2046
Z-11	0.0875	0.7954	100.0000

Factor loading	Z-01	Z-02	Z-03	Z-04
Zn	0.9124	-0.0816	-0.2441	-0.0349
Fe	0.8119	-0.4105	-0.2144	-0.0463
Cu	0.8075	-0.4033	-0.2862	0.0149
F	0.7085	0.3737	-0.1611	0.0046
As	0.6777	0.2371	0.2876	0.1067
Ta	0.1505	0.8898	-0.0747	-0.0759
Nb	-0.0210	0.8653	-0.0339	-0.0877
Pb	0.4890	0.5633	0.0212	-0.1420
Hg	0.2166	-0.1722	0.6376	-0.5537
Au	0.3525	0.0892	0.5408	0.6861
Sb	0.4441	-0.1745	0.4922	-0.1375

First component(Z-1):

The factor loadings of Zn, Fe, Cu, F, As and Pb are high, suggesting mineralization of base metals.

High score zones are distributed over a wide area, from Huai Mae Tam to Huai Mae Pu in the north of the area, and in the upper reaches of Huai Mae Toen. In addition, high scores are also distributed in Huai Mae Thot, the upper reaches of Huai Mae Kaeng, and in Huai Mae Tid in the east of the area. As the high score zones in Huai Mae Thot and the upper reaches of Huai Mae Kaeng originate in the anomaly zones of As and Fe, no occurrence of base metals can be expected.

Second component(Z-2):

The factor loadings of Ta, Nb and Pb are high. It is possible that Pb which coexists with Ta and Nb may be lead from disintegrated uranium, and it is likely that they are accompanied by rare earth elements. This component is thought to show the existence of rare metal and rare earth elements related to granite.

The high score zones are concentrated in the vicinity of granite bodies, and high scores are concentrated in particular over a wide area in the vicinity of the granite body on the left bank of Huai Mae Thot. High scores are also distributed on the right bank in the upper reaches of Huai Mae Toen, though covering a small area, and the existence of subsurface granite is assumed.

Third component(Z-3):

The factor loadings of Hg, Au and Sb are high, suggesting mineralization of epithermal gold-containing quartz veins and their halos.

High score zones are seen in Huai Mae Tam in the north and from Huai Mae Haet to Huai Mae Pu, along the fault running NW-SE in the upper reaches of Huai Mae Bon in the northwest, in the uppermost reaches of Huai Mae Thot, from Huai Krathin to Huai Pun Yang on the right bank of Huai Mae Thot, in the middle reaches of Huai Mae Kaeng, north of Ban Na Ban Rai.

Fourth component(Z-4):

Au has a high factor loading by itself and Hg which is closely connected with gold has a negative factor loading. Rather than indicating mineralization of gold, this component is thought to indicate high density distribution of gold (distribution of placer gold) in stream sediment. High scores are seen near where placer gold was confirmed by panning and further upstream.

2-7 Considerations

The geology of the Doi Chong area is composed, from below, of Carbono-Siluro-Devonian Mae Tha Group and Donchai Group, Permian Ratburi Group Kiu Lom Formation, Pha Huat Formation and Huai Thak Formation, Permo-Triassic Volcanic Formation, Triassic Lampang Group Hong Hoi Formation and Triassic intrusive granite and diorite, etc.

Much of the granite and diorite is relatively small-scale. The largest-scale rock bodies are around 2 x 8m on the left bank of Huai Mae Thot and they are seen in the mountainous region between Huai Mae Thot and Huai Mae Tia. It has been confirmed that the sedimentary rock around the granite has often undergone contact metamorphism, showing that the granite is intrusive rock. It is assumed that the granite intruded in a N-S or SW-NE direction, harmonizing with the geologic structure of sedimentary rock in the vicinity and with the direction of the fault. The age of the granite in the survey area is not clear, but judging from the fact that the granite bodies intruded into Permian and Triassic strata and that an age of 205 to 236Ma by Rb-Sr radiometric dating has been reported for granite bodies in the environs of the survey area, they are thought to belong to Late Triassic time.

In the geologic structure of the Doi Chong area there are assumed to be faults running NW-SE, N-S and NW-SE. The direction of the bedding and cleavage planes of the strata in the vicinity of the fault running NE-SW along the Mae Nam Wang and the fault running NW-SE in the upper reaches of the Nam Mae Toen inclines toward the direction of the fault.

The other faults are also assumed to be geologically discontinuous, taking the fault as the boundary, and in particular, the faults running NNW-SSE to N-S along the Huai Mae Thot are assumed to be relatively large-scale reverse faults.

The Carbono-Siluro-Devonian and Permian geologic structure on the whole runs in a NNW-SSE direction and the upper strata overlap in a northeasterly direction. In addition, Permo-Triassic volcanic rock and Triassic system are distributed, covering them unconformably. However, judging by the fault along the Huai Mae Thot, the east side of the fault is thought to have risen relatively, and the subordinate Permian layer is exposed on the east of the fault.

Schistosity or cleavage planes of varying degrees are seen in the sedimentary rock in most of the survey area, and the planar structure on the whole runs NNW-SSE to N-S. It is known that the environs of the Doi Chong area underwent widespread deformation in Carboniferous time, and the Carbono-Siluro-Devonian show marked development of schistose planes, phyllitization,

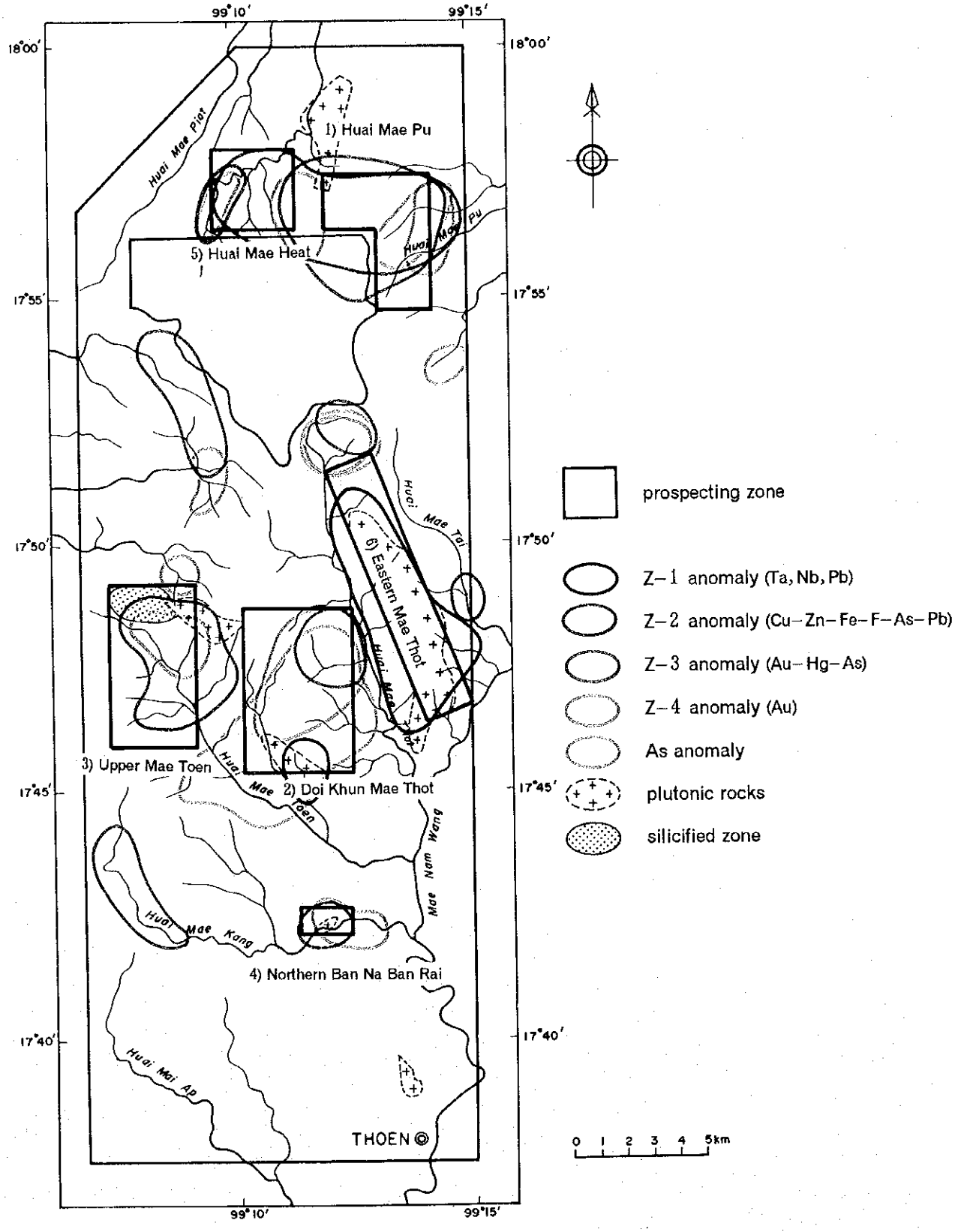


Fig.27 Interpretation map of Doi Chong area

conglomerate deformation, etc. Moreover, in addition to development of planar structures seen in the Permian and Triassic in the vicinity of the fault, development is accompanied by hornfelsization in the vicinity of the granite bodies.

There used to be fluorite mines in Ban Mae Kaeng and Ban Mae Toen in the Doi Chong area, and gold excavation pits to the east and north of Ban Na Ban Rai. Also, according to information from DMR, there were small-scale occurrences of magnetite and limonite, one in Huai Mae Thot and one in the southeast of the area, and according to information from local residents, there used to be antimony deposits in Huai Mae Haet in the north.

Sedimentary rock and metamorphic rock older than the Permian are prevalent in the Doi Chong area. Its consolidation is high. Mineralization and alteration is considered difficult to occur in it. In fact, no argillization and other alteration has been observed.

However, quartz veins have developed accompanied by small-scale silicified zones in the environs of granite bodies and small veins of aplite. Also, large-scale silicified zones are distributed around the diorite in the upper reaches of Huai Mae Toen.

According to the results of geochemical prospecting, a high score zone for the first component (Z-1) which indicates mineralization of base metals is seen running E-W from Huai Mae Tam to Huai Mae Pu in the north. This high score zone can be divided into the region between Huai Mae Tam and Huai Mae Haet where mineralization of base metals can be expected, and the region between Huai Mae Haet and Huai Mae Pu, overlapping the high score zone of the third component (Z-3), where medium to epithermal poly-metal vein deposits can be anticipated. The high score zone which covers a wide area in the upper reaches of Huai Mae Toen is distributed around diorite.

The high score zones in the north are accompanied by anomaly zones for gold, but there are no anomaly zones for mercury or arsenic and the deposits are thought to be high temperature contact replacement deposits. Also, there are high values for mercury and arsenic in the south, and hydrothermal vein deposits can be expected. Judging from the fact that anomaly zones of niobium, tantalum and fluorine are also distributed in the region to the south, the existence of subsurface granite is presumed.

Judging from the distribution of anomaly zones for individual elements, the high score zone in Huai Mae Tid in the east of the region indicates promising high temperature type base metal deposits.

The second component (Z-2) suggests the existence of rare metal and rare earth deposits of niobium and tantalum, and especially in the environs of granite bodies on the left bank of Huai Mae Thot, there is a strong possibility of the existence of primary and placer deposits.

The third component is thought to show the existence of hydrothermal gold deposits, and in addition to the region between Huai Mae Haet and Huai Mae Pu which overlaps the Z-1 high

score zone, high scores are also distributed in promising mineral regions in the upper reaches of Huai Mae Kaeng in the southwest, the upper reaches of Huai Mae Bon in the northwest, the uppermost reaches of Huai Mae Thot, from Huai Krathing on the left bank of Huai Mae Thot to Huai Pun Yang, and north of Ban Na Ban Rai.

Taken together with the fourth component which shows the existence of gold, the high score areas in the upper reaches of Huai Mae Bon and in Huai Mae Kaeng give strong indications of mercury and are likely to indicate the overburden of deposits. As for the high score zone from Huai Krathing to Huai Pun Yang, judging from the distribution of individual element anomaly zones for Z-4 and fluorine which is thought to be a halo for prospective gold deposits, the promising mineral zone extends as far as Huai Mae Toen, centering on Doi Khun Mae Thot. The region north of Ban Na Ban Rai has actually been excavated and there is scope for prospecting.

Mineralization in the Doi Chong area is thought to be mainly connected with Triassic plutonic rocks.

From the above, the following regions have been selected as promising mineral deposit regions in the Doi Chong area: the Huai Mae Pu region where vein type deposits of gold and base metals can be expected, the Huai Mae Haet region and the upper reaches of Huai Mae Toen where there is a high possibility of the existence of base metal deposits, the Doi Khun Mae Thot mountainous region and the region north of Ban Na Ban Rai where hydrothermal gold deposits can be expected, and the region east of Huai Mae Thot where rare metal and rare earth deposits can be expected (Fig.27).

CHAPTER 3 RATCHABURI AREA

3-1 General Geology

The Ratchaburi area is composed of Ordovician Thung Song Group, Silurian-Devonian Kanchanaburi Group (SD), Huai Phu Ron Formation (Ch) and Kao Phra Formation (Ck) of the Devonian-Carboniferous Kaeng Kranchan Group, and granite that has intruded into in Jurassic-Cretaceous age. Thick stream sediments have accumulated along each river and were once excavated as secondary tin deposits.

The geologic map and schematic geologic column of the Ratchaburi area are shown in Figs.28 and 29.

3-2 Detailed Geology

3-2-1 Ordovician Thung Song Group (Ot)

The Thung Song Group is distributed in granite roof pendant form in Huai Takua Pit Thong, north of the Ratchaburi survey area. The rockfacies consist mainly of slate with seams of calcareous mudstone and limestone. Overall it has undergone intense thermal metamorphism due to the granite.

3-2-2 Silurian-Devonian Kanchanaburi Group (SD)

The Kanchanaburi Group is distributed in Huai Nam Nak in the upper reaches of Mae Nam Phachi, in the basin of Huai Bo Khlung, a tributary of Mae Nam Phachi in the northwest of the area, and in the region south of Amphoe Suan Phung where the district office is located. It is composed of alternation of quartzite, phyllite and mica schist. The schistose structure is well developed overall. Especially in the contact zone with granite, the schistose structure is clear and the schist has a granoblastic texture.

3-2-3 Devonian-Carboniferous Kaeng Krachan Group

The Kaeng Krachan Group consists of the Huai Phu Ron Formation (Ch) which is composed of quartzite and slate, and the Kao Phra Formation (Ck) which is characterized by mudstone containing gravels.

1. Huai Phu Ron Formation (Ch)

The Huai Phu Ron Formation is distributed in the basin of Huai A Na in the upper reaches of Mae Nam Phachi at the southwestern tip of the area, in Huai Khang Khao in the north of the area, and in the upper reaches of Huai Tha Khoei in the southwest of the area. It is composed of massive dark gray quartzite, dark gray or black slate, calcareous shale, hornfels and spot schist which shows preferred orientation.

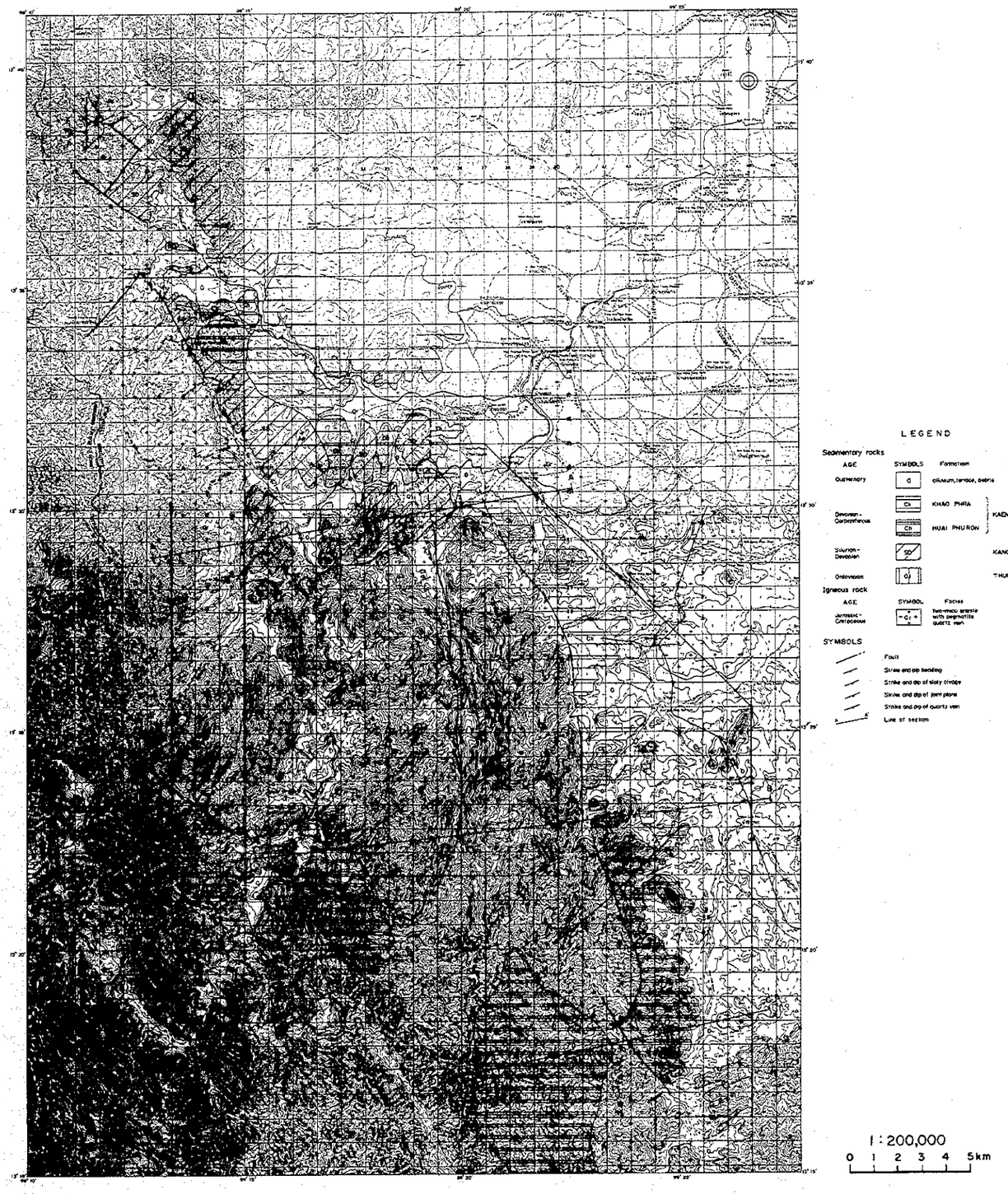


Fig.28 Geologic map in Ratchaburi area

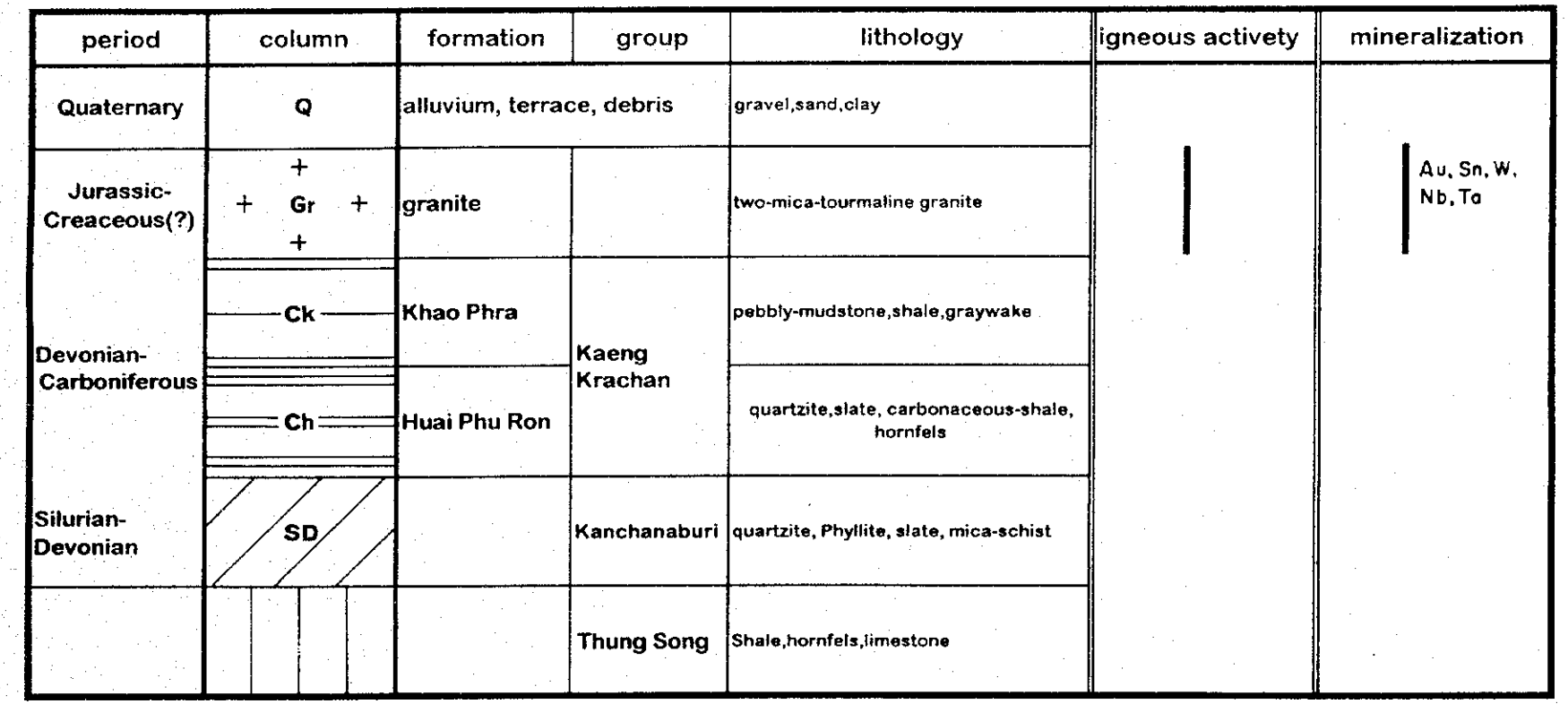


Fig.29 Schematic geologic column in Ratchaburi area

Compared with the Kanchanaburi Group, the schistose structure is weak, but a weak schistose structure is observed in various places.

2. Kao Phra Formation (Ck)

The Kao Phra Formation is distributed along the outer edge of the granite on the east side of the survey area. The Kao Phra Formation is composed of mudstone which contains gravel of varying diameters, shale which is characterized by sandstone and shows slaty cleavage and shell-shaped fractures, graywacke sandstone and calcareous sandy shale, etc. The mudstone which contains gravel and the sandstone are mainly massive, but slumping structure and cross lamina are seen.

3-2-4 Jurassic-Cretaceous Granite (Gr)

Granite distribution extends over the greater part of the area. It is divided into two bodies, one on either side of the alluvial lowlands of Huai Tha Khoei, but no difference in rockfacies is seen.

Phenocrysts of potash feldspar are seen in some parts in the medium to coarse two-mica (-tourmaline) granite. Hardly any rockfacies changes are seen, but pegmatite, aplite, quartz veins are found scattered around the granite bodies.

3-2-5 Quaternary sediment (Q)

Quaternary sediments have developed in the vicinity of where Huai A Na and Huai Nam Nak converge in the upper reaches of Mae Nam Phachi in the southwestern tip of the area, where Huai Bo Khlung, a tributary of Mae Nam Phachi, and Mae Nam Phachi converge in the northwest of the area, and in the Huai Tha Khoei basin in the east of the area. They consist of unconsolidated gravel, clay, silt, etc. and the stratum is around 8 to 20m in thick (Suthakorn & Udomporwirat, 1991).

3-3 Geologic Structure

The sedimentary rock structure is distributed in fragments on account of intrusion of granite, but the schistosity and sedimentary structures display a NW-SE direction and new strata tend to overlap on both sides of the Silurian-Devonian anticline structure.

The granite is part of a massive batholith that intruded along the Thai-Myanmar border and the intrusive direction of the batholith conforms on the whole to the structure of the sedimentary rock. Lineaments running NE-NW to NNE-SSW are clearly seen in the granite area.

3-4 Geochemical Characteristics of Granite

Geochemical analysis of 12 samples from the Ratchaburi area was conducted. Of the 12 samples, 10 were of two-mica (-tourmaline) granite, 1 was granite porphyry and 1 was quartz vein.

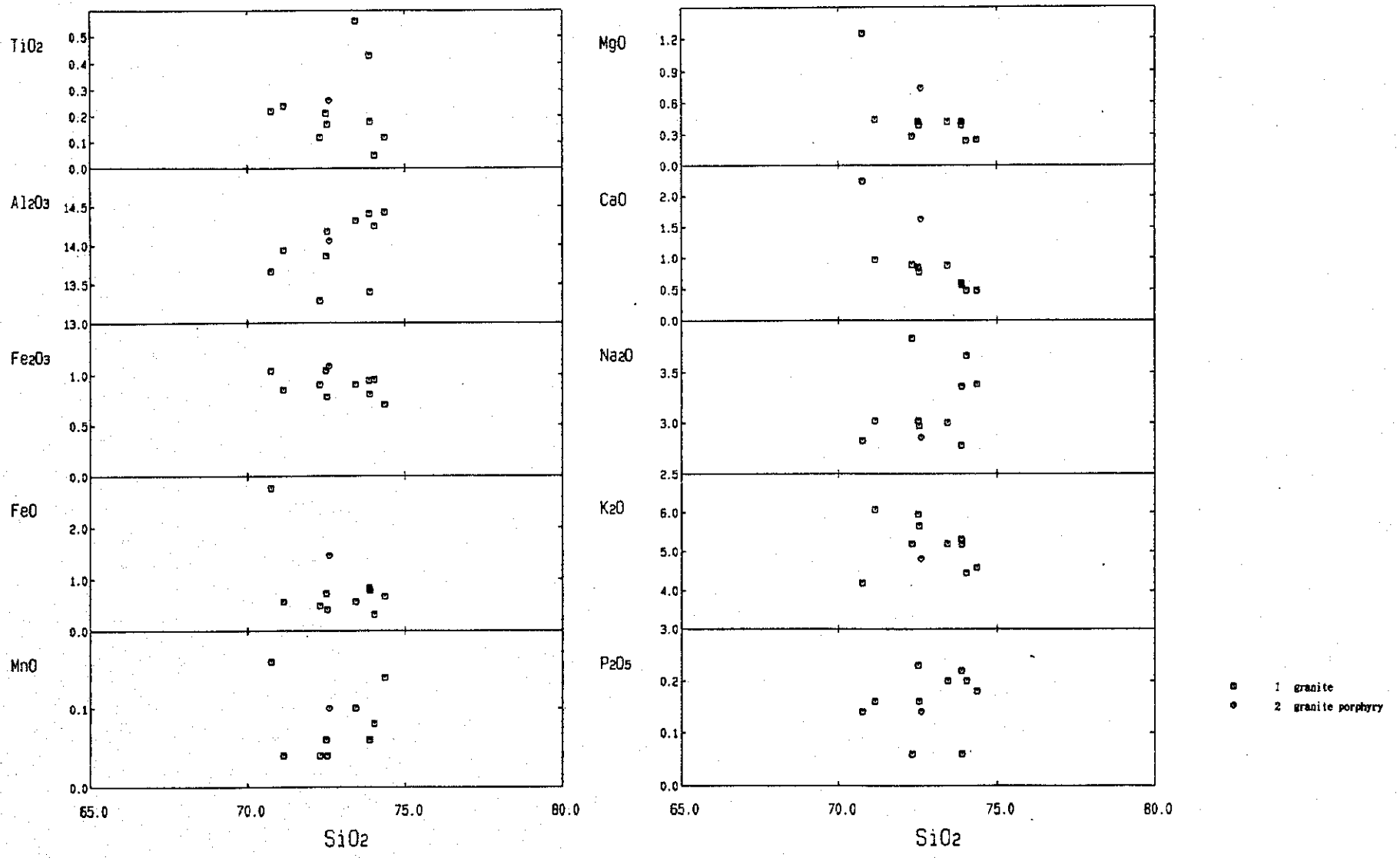
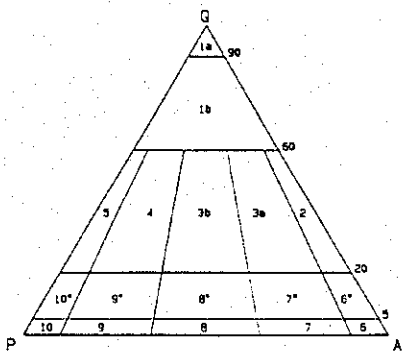


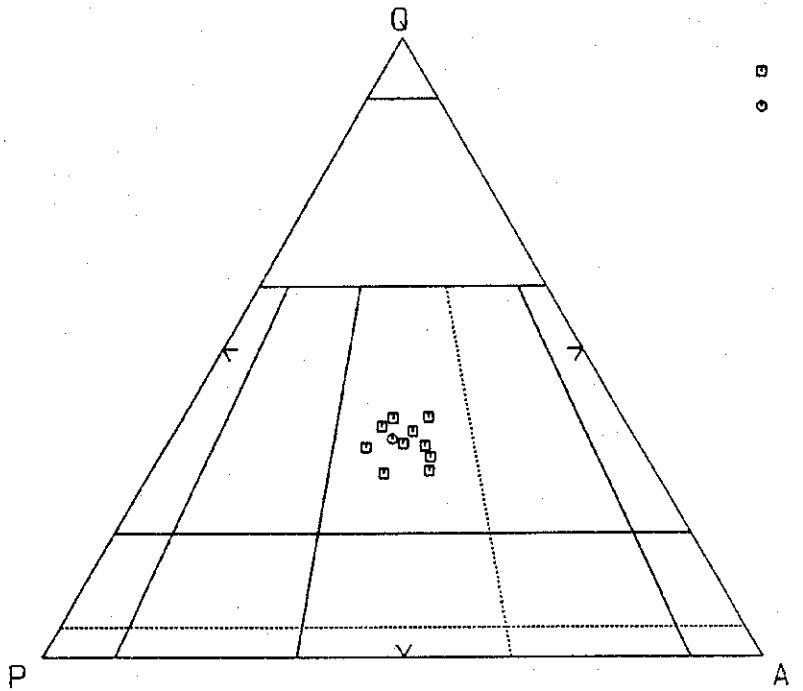
Fig.30 Variation diagrams of igneous rocks in Ratchaburi area



Classification of granitic rocks
(IUGS, 1973)

Q – quartz ; A – alkali feldspar (including microcline, orthoclase, sanidine, anorthoclase, and perthites (including their plagioclase components), and plagioclase An-0-5) ; P – plagioclase other than An-0-5; F – feldspathoids (leucite and pseudoleucite, nepheline, sodalite, nosean, hauyne, cancrinite, analcime, etc.

1a, quartzolite (silexite) ; 1b, quartz-rich granitoids ; 2, alkali-feldspar granite ; 3, granite ; 4, granodiorite ; 5, tonalite ; 6*, quartz alkali-feldspar syenite ; 7*, quartz syenite ; 8*, quartz monzonite ; 9*, quartz monzodiorite/quartz monzogabbro ; 10*, quartz diorite/quartz gabbro/quartz anorthosite ; 6, alkali-feldspar syenite ; 7, syenite ; 8, monzonite ; 9, monzodiorite/monzogabbro ; 10, diorite/gabbro/anorthosite



1 granite
2 granite porphyry

Fig.31 Normative Q-P-A diagram in Ratchaburi area

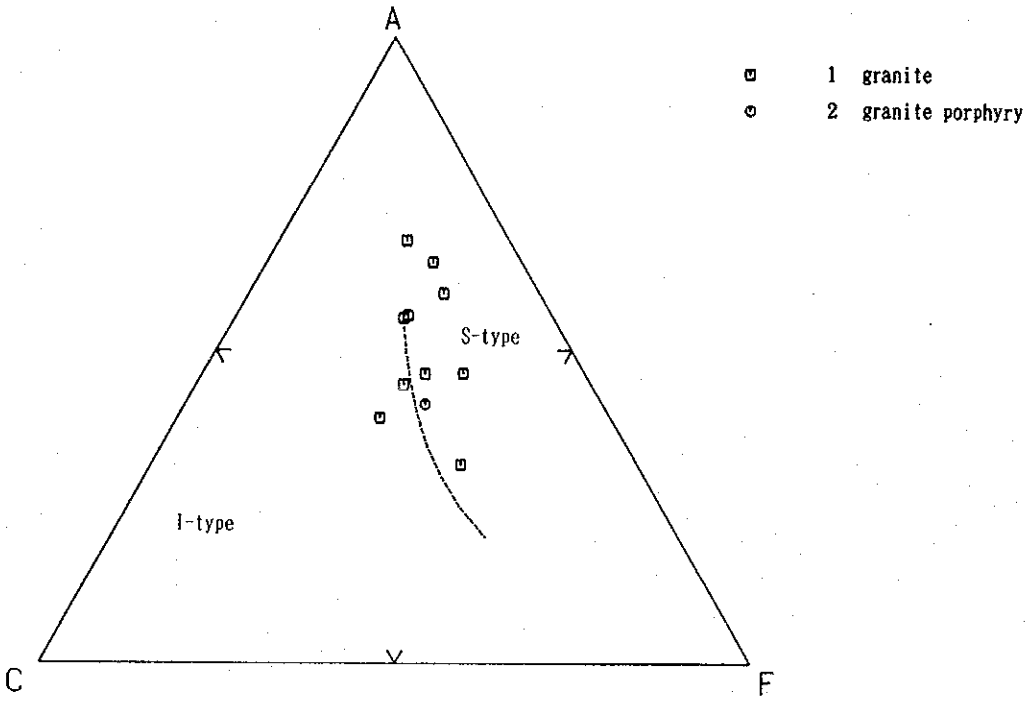


Fig.32 ACF diagram in Ratchaburi area

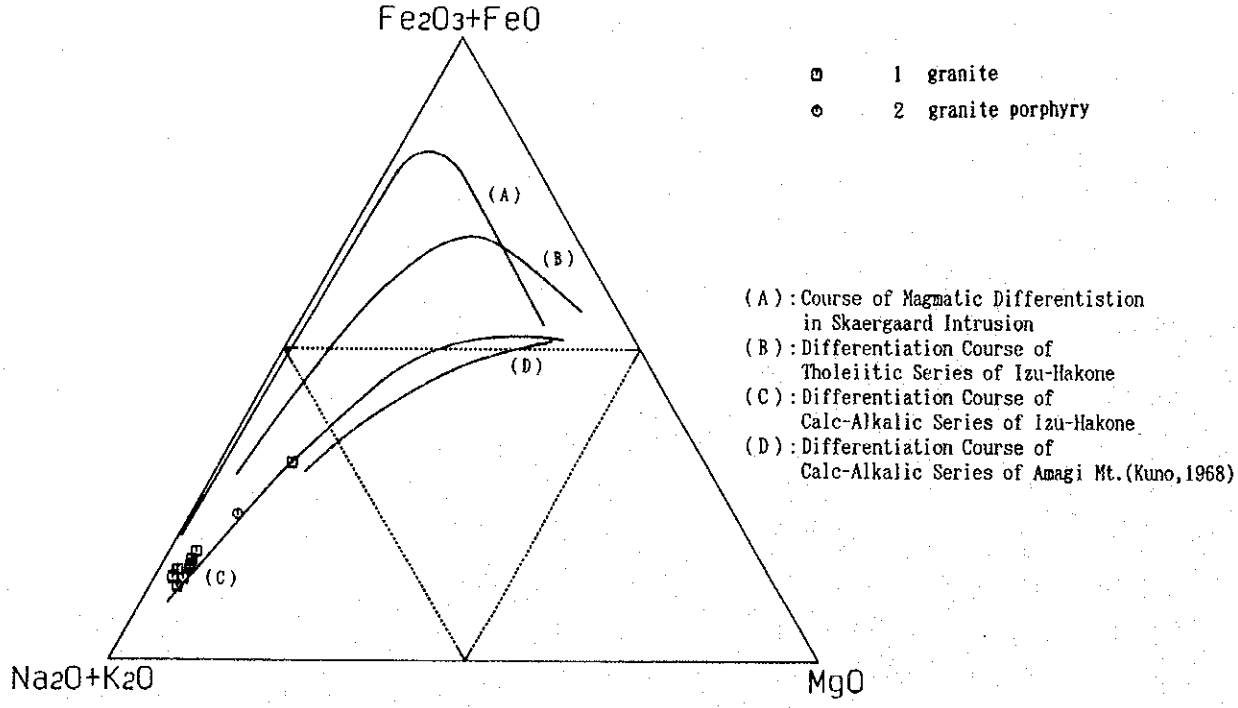


Fig.33 MFA diagram in Ratchaburi area